

ΘΕΟΣ



*I Wale inv. & del.*  
And God called the dry Land Earth, and the gathering  
together of the Waters called he Seas; and God saw  
that it was good.



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PHYSICO-THEOLOGY:  
OR, A *Gal 1026.*  
DEMONSTRATION  
OF THE  
BEING and ATTRIBUTES of GOD,  
FROM HIS  
WORKS of CREATION.

Being the SUBSTANCE of  
SIXTEEN SERMONS,

Preached in St. Mary-le-Bow Church, London.

At the Honourable Mr. BOYLE'S LECTURES,  
in the Years 1711, and 1712.

With large Notes, and many curious Observations.

By W. DERHAM, D. D. late Canon of Windsor,  
Rector of Upminster in Essex, and F. R. S.

*Mala & impia consuetudo est contra Deos disputare, siue  
animo id fit, siue simulatè. Cic. de Nat. Deor. L. 2. fin.*

IN TWO VOLUMES.

V o l. I.

THE ELEVENTH EDITION,

L O N D O N :

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T O T H E

Most Reverend Father in God,

**T H O M A S,**

Lord Archbishop of **CANTERBURY,**

Primate of all **ENGLAND, &c.**

The Surviving **TRUSTEE** of the Honourable  
**Mr. BOYLE's LECTURES.**

May it please your **GRACE,**

**I** **MAY** justly put these Lectures under your Grace's patronage, their publication being wholly owing to you: For having the honour to be a member of the Royal Society, as well as a Divine, I was minded to try what I could do towards the improvement of philosophical matters to theological uses; and accordingly laid a scheme of what I have here published a part of; and when I had little else to do, I drew up what I

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**A**

had

#### iv DEDICATION.

had to say, making it rather the diverting exercises of my leisure hours, than more serious theological studies. This work (although I made a considerable progress in it at first, whilst a novelty, yet) having no thoughts of publishing, I laid aside, until your Grace, being informed of my design by some of my learned friends, both of the clergy and laity, was pleased to call me to the unexpected honour of preaching Mr. *Boyle's* Lectures: an honour I was little aware of in my country privacy, and not much acquainted with persons in high stations, and not at all particularly with your Grace. So that therefore as it pleased your Grace, not only to confer an unsought profitable honour upon me (a stranger) but also to continue it for two years, out of your good opinion of my performance, in some measure, answering Mr. *Boyle's* end; so I can do no less than make this publick, grateful acknowledgment of your Grace's great and unexpected favour.

But it is not myself alone, but the whole Lecture also is beholden to your Grace's kind and pious endeavours. It was you that encouraged this noble charity, and assisted in the settlement of it, in the honourable

# D E D I C A T I O N. V

honourable Founder's life-time; and since his death it was you that procured a more certain salary for the Lecturers, paid more constantly and duly than it was before \*.

These benefits, as I myself have been a sharer of, so I should be very ungrateful, should I not duly acknowledge, and repay with my repeated thanks and good wishes. And that the infinite rewarder of well-doing, may give your Grace a plentiful reward of these, and your many other, both publick and private, benefactions, is the hearty wish of

*Your Grace's*

*most humble and thankful*

*Son and Servant,*

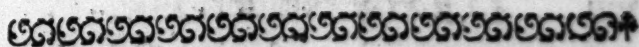
W. Derham.

\* It may not only gratify the reader's curiosity, but also be of use for preventing encroachments in time to come, to give the following account of Mr. Boyle's lectures.



## vi DEDICATION.

Mr. *Boyle*, by a codicile, dated *July* the 28th, 1691. and annexed to his will, charged his messuage, or dwelling-house, in *St. Michael's Crooked-Lane, London*, with the payment of the clear yearly rents and profits thereof, to some learned divine in *London*, or within the bills of mortality, to be elected for a term not exceeding three years, by his Grace the present Lord Archbishop of *Canterbury* (then Dr. *Tenison*) Sir *Henry Asburst*, Sir *John Rotherbam*, and *John Evelyn*, Esq; The business he appointed those Lectures for, was, among others, 'To be ready to satisfy real scruples, and to answer such new objections and difficulties as might be started, to which good answers had not been made.' And also, 'To preach eight Sermons in the year, viz. the first Monday of *January, February, March, April*, and *May*; and of *September, October*, and *November*.' The subject of these sermons was to be, 'The proof of the Christian Religion against notorious Infidels, viz. Atheists, Theists, Pagans, Jews, and Mahometans; not descending lower, to any controversies that are among christians themselves.' But by reason the lecturers were seldom continued above a year, and, that the house sometimes stood empty, and tenants brake, or failed in due payment of their rent, therefore the salary sometimes remained long unpaid, or could not be gotten without some difficulty; To remedy which inconvenience, his present Grace of *Canterbury* procured a stipend of 50*l.* to be paid quarterly for ever, charged upon a farm in the parish of *Brill*, in the county of *Bucks*; which stipend is accordingly very duly paid, when demanded, without fee or reward.



# T O T H E R E A D E R.

**A**S the noble Founder of the Lectures I have had the honour of preaching, was a great improver of Natural Knowledge, so, in all probability, he did it out of a pious end, as well as in pursuit of his genius. For it was his settled opinion, that nothing tended more to cultivate true religion and piety in a man's mind, than a thorough skill in philosophy. And such effect it manifestly had in him, as is evident from divers of his publish'd pieces; from his constant deportment in 'never *Vide Bishop Burnet's funeral sermon, p. 24.* mentioning the name of God without a pause, and visible stop in his discourse; and from the noble foundation of his lectures for the honour of God, and the generous stipend he allowed for the same.

And forasmuch as his Lectures were appointed by him for the 'proof of the christian religion against Atheists and other notorious Infidels,' I thought, when I had the honour to be made his lecturer, that I could not better come up to his intent,



than to attempt a demonstration of the Being and Attributes of God, in what I may call Mr. *Boyle's* own, that is, a *Physico-Theological* way. And, besides that, as it was for this very service that I was called to this honour, I was the more induced to follow this method, by reason none of my learned and ingenious predecessors in these lectures have done it on purpose, but only casually, in a transient, piece-meal manner, they having made it their business to prove the great points of christianity in another way, which they have accordingly admirably done. But considering what our honourable Founder's opinion was of Natural Knowledge, and that his intent was, that those matters, by passing through divers hands, and by being treated of in different methods, should take in most of what could be said upon the subject; I hope my performance may be acceptable, although one of the meanest.

As for others, who have before me done something of this kind, as *Mersenne*, on *Genesis*; *Dr. Cockburne*, in his *Essays*; *Mr. Ray*, in his *Wisdom of God*, &c. and I may add the first of Mr. *Boyle's* Lecturers, the most learned *Dr. Bentley*, in his *Boyle's Lectures*, the eloquent Archbishop of *Cambray* (and, I hear, the ingenious *Monsieur Perault* hath something of this kind, but never saw it) I say, as to these learned and ingenious authors, as the Creation is an ample subject, so I industriously endeavoured

endeavoured to avoid doing over again what they before had done ; and for that reason did not, for many years, read their books, until I had finished my own. But when I came to compare what each of us had done, I found myself in many things to have been anticipated by some or other of them, especially by my friend, the late great Mr. Ray. And therefore in some places I shorten'd my discourse, and referr'd to them ; and in a few others, where the thread of my discourse would have been interrupted, I have made use of their authority, as the best judges ; as of Mr. Ray's, for instance, with relation to the mountains, and their plants, and other projects. If then the reader should meet with any thing mention'd before by others, and not accordingly acknowledged by me. I hope he will candidly think me no plagiarist, because I can assure him I have all along (where I was aware of it) cited my authors with their due praise. And it is scarce possible, when men write on the same, or a subject near a-kin, and the observations are obvious, but that they must often hit upon the same thing : And frequently this may happen from persons making observations about one and the same thing, without knowing what each other hath done ; which indeed, when the first edition of my book was nerly printed off, I found to be my own case, having ( for want of having Dr. Hook's Micrography being at hand, it  
being

being a very scarce book, and many years since I read it) given descriptions of two or three things, which I thought had not been tolerably well observed before, but are described well by that curious gentleman.

One is a Feather, the mechanism of which we in the main agree in, except in his representation in *fig. 1. scheme 22.* which is somewhat different from what I have represented in *fig. 18. &c.* But I can stand by the truth, though not the elegance of my figures. But as to the other differences, they are accidental, occasioned by our taking the parts in a different view, or in a different part of a vane; and to say the truth (not flattering myself, or detracting from the admirable observations of that great man) I have hit upon a few things that escaped him, being enabled to do so, not only by the help of such microscopes as he made use of; but also by those made by Mr. *Wilson*, which exceed all I ever saw, whether of English, Dutch, or Italian make; several of which sorts I have seen and examined.

The other thing we have both of us figured and described, is, the Sting of a Bee or Wasp; in which we differ more than in the last. But by a careful re-examination, I find, that although Dr. *Hook's* observations are more critical than any were before, yet they are not so true as mine. For as to the Scabbard (as he calls it) I could never discover any beards thereon;

whereon; and I dare be confident there are  
one, but what are on the two spears. And  
as to the point of the scabbard, he hath re-  
presented it as tubular, or bluntish at the top;  
but it really terminates in a sharp point, and  
the two spears and the poison come out of a  
bit, or longish hole, a little below the top or  
point. And as to the spears, he makes them  
to be but one, and that the point thereof lies  
always out of the scabbard. But by a strict  
examination, they will be found to be two,  
as I have said, and that they always lie within  
the scabbard, except in stinging; as I have  
represented them, in *fig. 21.* from the trans-  
parent stinging of a wasp. And as to the spear  
being made of the joints, and parted into two,  
as his *fig. 2. scheme 16.* represents, I could  
never, upon a review, discover it to be so,  
but imagine, that by seeing the beards lying  
upon, or behind the spears, he might take  
them for joints, and by seeing the point of one  
spear lie before the other, he might think the  
spear was parted in two. But lest the reader  
should think himself imposed upon by Dr.  
*Hook* and myself, it is necessary to be ob-  
served, that the Beards (or Tenterhooks, as  
Dr. *Hook* calls them) lie only on one side of  
each spear, not all round them; and are  
therefore not to be seen, unless they are laid  
in a due posture in the microscope; viz. side-  
ways, not under, or a top the spear.

The

The last thing (which scarce deserves mention) is the mechanism of the Hair, which Dr. *Hook* found to be solid, like a long piece of horn, not hollow, as *Malpighi* found it in some animals. And I have found both those great men to be in some measure in the right, the hair of some animals, or in some parts of the body, being very little, if at all, tubular; and in others, particularly Mice, Rats, and Cats, to be as I have represented in my *fig.* 14, &c.

And now, if my inadvertency in other things hath no worse effect than it hath had in these; namely, to correct, or clear others observations, I hope the reader will excuse it, if he meets with any more of the like kind. But not being conscious of any such thing (although probably there may be many such) I am more solicitous to beg the reader's candour and favour, with relation both to the Text and Notes: In the former of which, I fear he will think I have as much under-done, as in the latter over-done the matter: But for my excuse I desire it may be considered, that the textual part being sermons; to be deliver'd in the pulpit, it was necessary to insist but briefly upon many of the works of God, and to leave out many things that might have been admitted in a more free discourse. So that I wish it may not be thought I have said too much, rather than too little, for such an occasion and place. And indeed, I had no  
small

shall trouble in expunging some things, altering many, and softening the most, and, in a word, giving, in some measure, the whole a different dress than what I had at first drawn up in, and what it now appears in.

And as for the Notes, which may be thought too large, I confess I might have shortened them, and had thoughts of doing it, by casting some of them into the text, as an ingenious learned friend advised. But when I began to do this, I found it was in a manner to new-make all, and that I should be necessitated to transcribe the greatest part of the book, which (having no assistant) would have been too tedious for me, being pretty well fatigued with it before. I then thought it best to pare off from some, and to leave out others, and accordingly did so in many places, and could have done it in more, particularly in many of the citations out of the Ancients, both poets and others; as also in many of the anatomical Observations, and many of my own and others observations: But then I considered, as to the first, that those citations do many of them at least) shew the sense of mankind about God's works, and that the most of them may be acceptable to young gentlemen at the Universities, for whose service these lectures are greatly intended. And as to the anatomical notes, and some others of the like nature, most of them serve, either to the confirmation, or the illustration, or explication of



of the text, if not to the learned, yet to the unskilful, less learned reader ; for whose sake if I had added more, I believe he would forgive me. And lastly, as to the observations of myself, and some others, where it happens that they are long, it is commonly where necessity lay upon me of fully expressing the author's sense, or my own, or where the thing was new, and never before published ; in which case, it was necessary to be more express and particular, than in matters better known, or where the author may be referred unto.

In the former editions I promised another part I had relating to the Heavens, if I was thereunto encouraged. And two large impressions of this book having been sold off so as to admit of a third before the year was gone about ; and hearing that it is translated into two, if not three languages ; but especially being importuned by divers learned persons, both known and unknown, I have thought myself sufficiently engaged to perform that promise ; and have accordingly published that part.

So that I have now carried my Survey thro' most parts of the visible creation, except the Waters, which are for the most part omitted ; and the Vegetables, which, for want of time, I was forced to treat of in a perfunctory manner. And to the understanding of the former of these, having received divers soli-

itations from persons unknown, as well as known, I think myself bound in civility to own their favour, and to return them my hearty thanks for the kind opinion they have given of my other performances, that they have encouraged me to undertake this other work. And accordingly I have begun it, and as far as my affairs will permit) have made some progress in it: But age and avocations growing upon me, I begin to fear I shall scarce be able to finish it as I would, and therefore must recommend that ample and noble subject to others, who have more leisure, and would do it better than I.

As to Additions, I have been much sollicitated thereunto by divers curious and learned persons, who would have had me to insert some of their observations, and many more of my own; but in a work of this nature, this would have been endless: And although the book would thereby be rendered much better, and more compleat, yet I could by no means excuse so great an injustice to the purchasers of the former editions. And therefore (except in the second edition, where it was not easy to be avoided) few additions have been made, besides what were typographical, of small consideration. Only in the third edition I amended the first paragraph of *note 1. cap. 5. book 1.* concerning Gravity; and in the fourth, *page 16 and 18*, I inserted two passages out of *Seneca*, that were inadvertently

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left out, and corrected many things that upon a careful review, seemed to want amendment.

And lastly, as to the following Analysis, it was added at the request of some of my learned and ingenious friends; and although it might have been contracted, they would not suffer it to be so.



# AN ANALYSIS OF THE

## Following Book.

**T**HE works of the creation relating to our terraqueous globe, are such as are visible in the

Outworks or appendages of the globe, viz. these three :

1. The atmosphere,

Composed of air and vapours, vol. 1 .page 5.

Useful to

{ Respiration and animal life, 6.

{ Vegetation of plants, 12.

{ Conveyance of

{ The winged tribes.

{ Sound, 16.

{ The functions of nature,

{ Reflecting and refracting light, 17.

{ Containing the

{ Winds which are of great use and necessity

{ To the salubrity and pleasure of the air, 20.

{ In various engines, 25.

{ In navigation.

{ Clouds and rain : of great use to the

{ Refreshment of the earth and the things therein, 28.

{ Origin of fountains, according to some, 28.

2. Light. Its

{ Fountain, 37.

{ Wonderful necessity and use.

{ Improvement by glasses, 39.

{ Velocity.

{ Expansion, 42.

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{ Cause of Levity, which is of great use in the world  
50.

{ Terraqueous globe itself. Of which I take a view  
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{ Lodgment of the waters, 58.

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{ Its bulk, 61.

{ Its motion, 62.

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{ Its distribution, so as to cause all the parts of the  
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{ Balance each other, 68.

{ Be helpful to one another.

{ The great variety and quantity of all things serviceable  
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{ An objection answer'd, 78.

{ Particular, of the earth; of its

{ Constituent parts; viz. Its

{ Soils and molds necessary to the

{ Growth of various vegetables, 87

{ Various occasions of man, and other animals, 89

{ Various strata or beds, affording materials for

{ Tools.

{ Firing.

{ Building.

{ Dying, and thousands of other things, 92.

{ Conveyance of the sweet fountain-waters, 94

{ Subterraneous caverns and volcano's; of great use  
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{ Mountains and valleys, which are not rude ruins  
but works of design, inasmuch as this structure  
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The most salubrious : to some constitutions, the hills ; to some, the valleys, v. I. 102.

Best to screen us, and other things, 103.

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{ Production of various vegetables.

{ Harbour and maintenance of various animals 104.

{ Generation of minerals and metals, 106.

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{ Common to all the tribes, particularly these ten :

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{ Form, for the most part spherical, which is best for

{ The reception of objects.

{ Motion of the eye, 126.

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{ Every way

{ Fixed ; and the excellent provision in that case, 128.

Size ; which is in

{ All creatures, according to their occasions.

{ Such as live abroad in the light, larger.

{ Such as live under ground, less.

Number, in some animals.

{ Two, 131.

{ More : together with the wise provision to prevent double vision.

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{ Transiently, the arteries, veins, and some of the muscles and tunicks.  
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{ Nerves, 148.

{ Optick.

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{ Guard and security, provided for by

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{ Strong and curious bones.

{ Hard and firm tunicks.

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{ Of erect vision, 156.

Hearing. Its

{ Organ, the ear, 158.

{ Double, enabling us to hear every way and a good provision for the loss or hurt of one.

{ Situated in the very best place for information, security, and near the eye and brain

{ The fabrick of the

{ Outward ear, which is in

{ { All creatures formed, guardedly placed, and every way accommodated according to their various places and occasions, 160.

{ { Man suitable to his erect posture

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Tympanum, and its membrane, muscles, and four little bones to correspond to all kinds of sound.

Labyrinth, semicircular canals, cochlea; all made with the utmost art, 178.

Auditory nerves; one of which is ramified to the eye, tongue, muscles of the ear, and to the heart; whence a great sympathy between those parts, 180.

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{ A guard against noxious things, v. 1. 194.  
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{ Situation thereof to be a centinel to the  
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{ Ministering to the circulation of the blood, and  
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 cles, &c. for respiration, and forming  
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{ Trachea and epiglottis, exquisitely contrived  
 and made.

{ Bronchi and lungs, with their curious arte-  
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Transfiently the

Muscles, and their structure; their size, fastening to the joints, motions, &c. 223.

Bones, and their curious make.

Joints, with their form, bandage, and lubricity, 226.

Nerves, and their origin, ramifications; and inosculation.

More particularly the loco-motive act itself, which is

Swift or slow, with wings, legs many or few, or none at all, according to the various occasions and ways of animals lives. As particularly in

Reptiles, whose food and habitation is near at hand.

Man and Quadrupeds, whose occasions require a larger range, and therefore a swifter motion, 231.

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Geometrically and neatly performed by the nicest rules,

Well provided for by the

{ Due equipoise of the body, 233.

{ Motive parts being accurately placed with regard to the center of the body's gravity, and to undergo their due proportion of weight and exercise.

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{ Their organs are adapted to their place, 235.

{ All places habitable are duly stocked.

{ Various animals have their various places; and the wisdom thereof, 236.

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{ Overstocked by their increase.

{ Depopulated by their death.

Which is effected in

{ The several tribes of animals by a due proportion in the

{ Length of their life, 237.

{ Number of their young, in

{ Useful creatures being many.

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{ Different lengths of his life,

{ Soon after the creation, 240.

{ When the world was more, but not fully peopled, *ibid.*

{ When it was sufficiently stocked, down to the present time, 241.

{ Due proportions of marriages, births, and burials, 244.

{ Balance of males and females, 246.

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{ Maintaining such large numbers of all kinds of animals on the land, in the seas, and diverse places too unlikely to afford sufficient food.

{ Adjustment of the quantity of food to the number of devourers, so that

{ There is not too much, so as to rot and annoy the world, 254.

{ The most useful is the most plentiful, and easiest propagated, *ibid.*

{ Delight which the various tribes of animals have to the varieties of food, so that what is grateful to one, is nauseous to another:

{ Which is a wise means to cause

{ All creatures to be sufficiently supplied.

{ All sorts of food to be consumed.

{ The world to be kept sweet and clean by those means, 257.

Pecu-

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Curious apparatus in all animals for gathering, and digestion of their food ; viz. the

Mouth, nicely shaped for food, &c. In

Some, little and narrow, 266.

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Insects very notable to catch, hold, and devour prey ; to carry burdens, to bore and build their habitations, 267.

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Hooked for rapine, climbing, &c. 269.

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Compressed to raise limpets, &c.

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Muscles and tendons, serving to mastication, strong and well lodged.

Gullet, sized according to the food ; with curious fibres, &c. 276.

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Which hath a curious mechanism of fibres, tunicks, glands, nerves, arteries, and veins.

Whose faculty of digestion, by such seeming weak menstruums, is admirable.

Whose size and strength is conformable to the nature of the food, or occasions of animals.

Which is in

Tame

{ Tame animals but one.

{ Ruminants, birds, &c. more.

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{ Lacteals, together with the impregnation from the pancreas, gall, glands, and lymphæducts.

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{ Man less remarkable for the sake of his understanding, 202.

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{ Come to mature age, and are able to help themselves, by their

{ Accurate smell, 285.

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{ Hunting and groping out of sight.

{ Seeing and smelling at great distances, 288.

{ Climbing; the strong tendons and muscles acting therein.

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{ Man, born the most helpless of any, the parents, reason, hands and affection sufficing.

{ Irrationals: For whose young the creator hath made a sufficient provision, partly by the Parent animals own

{ Στροφή, and diligence in nursing and defending them, 291.

{ Sagacity and care in repositing their eggs and young, where food and all necessaries are to be found, 293.

{ Ability of the young themselves to shift for, and help themselves, with the little helps of their dams, 294.

{ Creatures destitute of food at some seasons, or likely to want it, who

{ Are able to live long without food, i. 296.  
 { Lay up food before hand.

VII. The cloathing of animals, which is, v. ii. p 1.  
 Suited to the place and occasions of all. In

Man it is left to his own reason and art,  
 joined with sufficient materials: Which is  
 best for him,

{ Because he may suit his cloathing to his  
 quality, business, 7.

{ For perspiration and health sake.

{ To exercise his art and industry.

{ To excite his diligence in keeping him-  
 self sweet and clean.

{ In being the parent of divers callings, 8.

{ Irrationals: Who are either

{ Ready furnished with proper cloathing,

{ On the dry land with hair, fleeces,  
 furs, shells, hard skins, &c. 9.

{ In the air with feathers, light, strong,  
 and warm.

{ In the waters with scales, hard for  
 guard; smooth for passage; or with  
 strong shells to guard such as move  
 more slowly, 14.

{ Provide for themselves by their textrine,  
 or architectonick art. Of which un-  
 der the next branch.

{ Well garnished, being all workman-like, com-  
 pleat, in its kind beautiful, being, ibid.

{ Adorned with gay, various, and elegant  
 colours.

{ If sordid, yet with exact symmetry, and full  
 of curious mechanism.

VIII. The houses and habitations of

Man, who is abundantly furnished with

{ Contrivance and art to build and garnish his  
 habitations, 17.

{ Materials of all sorts to effect his works.

{ Irrationals, whose marvellous instinct is mani-  
 fested by the

- Convenience of their nests and habitation for the
- Hatching and education of their young ii. 19.
- Guard and defence of themselves and their young.
- Fabrick of their nests, scarce imitable by man, and shewn by their contrivance and make, being exactly suitable to their occasions, and made by
- Putting only a few ugly sticks, moss, dirt &c. together, 24.
- Building combs according to the best rules of mathematicks.
- Weaving webs, and making cases. For which service the parts of their bodies, and materials afforded by them are very considerable.

IX. Animals self-preservation. For which there is always a guard in proportion to the dangers and occasions of their state. Which is observable in

- Man, whose reason and art supplies the defect of natural armature.
- Irrational creatures: Who
  - As they are on one hand sufficiently guarded by their
    - Shells, horns, claws, stings, &c. 34.
    - Changing their colours.
    - Wings, feet, and swiftness.
    - Diving in, and tinging the waters.
    - Ejecting juices out of their body.
    - Accurate smell, sight, and hearing.
    - Natural craft, 40.
    - Uncouth noise, ugly gesticulations and horrid aspect.
    - Horrible stink and excrements.
  - So on the other hand can by their strength, sagacity, or natural artifices, enter

and captivate what is necessary for their food and other occasions.

X. Animals generation.

{ Equivocal is denied, 41.

{ Univocal: Which of

{ Man, is *σωφρονιστικὴ φύσις*, passed wholly by.

{ Irrational creatures, which are remarkable for their sagacity, in choosing the fittest place for their eggs and young: Where it is observable what a

{ Compleat order they observe.

{ Neat apparatus their bodies are provided with for this purpose, 248.

{ Natural venom they inject with their eggs into vegetables to pervert nature, and produce balls and cases, 50.

Making use of the fittest seasons, either

{ All seasons, 51.

{ When provisions are most plentiful, and easiest had.

Due number of young, 52.

Diligence and concern for their young, in point of

{ Incubation, 54.

{ Safety and defence, 55.

Faculty of nursing their young, by

{ Suckling them. In which it is observable

{ How suitable this food is.

{ How willingly parted with by all, even the most savage.

{ What a compleat apparatus in all creatures, of dugs, &c.

Putting food in their mouths, with their proper parts for catching and conveying food, 57.

{ Neither way, but by laying in provisions before hand, 59.

Having in the Fourth Book thus dispatched the Decad of things in common to the Sensitive Creatures,



tures, I take a view of their particular tribes  
viz. of

Man; whom I consider with relation to his  
Soul. Concerning which, having cursorily  
mentioned divers things, I insist upon two  
as shewing an especial divine management  
the

Various Genii, or inclinations of men  
which is a wise provision for the dispatch  
of all the world's affairs, and that they  
may be performed with pleasure, 65.

Inventive faculty. In which it is remarkable that

Its compass is so large, extending to all  
things of use, and occasioning so many  
several callings.

Things of greatest necessity and use were  
soon and easily found out; but things less  
useful later, and dangerous things not  
yet. Here of divers particular inventions,  
with an exhortation to exercise  
and improve our gifts.

Body. In which the things particularly remarked upon are the

Erect posture, 91.

The most convenient for a rational Being.  
Manifestly intended, as appears from the  
structure of some particular parts  
mentioned, 95.

Nice structure of the parts ministering  
thereto.

Equilibration of all the parts, 97.

Figure and shape of man's body most agreeable  
to his place and business, 98.

Stature and size, which is much the best for  
man's state, 99.

Structure of the parts, which are

With-

Without botches and blunders.

Of due strength.

Of the best form.

Most accurately accommodated to their proper offices.

Lodgment of the parts, as the

Five senses, 110.

Hands.

Legs and feet.

Heart.

Viscera.

Several bones and muscles, &c. 112.

Covering of all with the skin.

Provision in man's body to

Prevent evils by the

Situation of the eyes, ears, tongue, and hand, 114.

Guard afforded all, especially the principal parts.

Duplication of some parts.

Cure of evils by means of

Proper emunctories, 115.

Diseases themselves making discharges of things more dangerous, 117.

Pain giving warning, and exciting our endeavours.

Consent of the parts, effected by the nerves, a sample whereof is given in the fifth pair, branched to the eye, ear, &c.

Political, sociable state. For the preservation and security of which the Creator hath taken care by variety of mens

Faces, 125.

Voices.

Hand-writing.

Quadrupeds. Of which I take no notice, but wherein they differ from man ; viz.

Prone posture, which is considerable for

The parts ministering to it, especially the legs and feet, sized and made in some for



- Strength and slow motion, 133.
- Agility and swiftness.
- Walking and running.
- Walking and swimming.
- Walking and flying.
- Walking and digging.
- Traversing the plains.
- Traversing ice, mountains, &c.
- Its usefulness to
  - Gather food, 136.
  - Catch prey.
  - Climb, leap, and swim.
  - Guard themselves.
  - Carry burdens, till the ground, and other uses of man.
- Parts differing from those of man.
- Head, wherein I consider
  - Its shape; commonly agreeable to the animal's motion, 137.
  - The brain, which is
    - Lesser than in man, 138.
    - Placed lower than the Cerebellum.
  - The nictitating membrane, 140.
  - Carotid arteries, and Rete Mirabile.
  - Nates.
- Neck.
  - Answering to the length of the legs, 142.
  - Strengthened by the whitleather.
- Stomach, 144.
  - Corresponding to the several species.
  - Suited to their proper food. whether flesh, grain, &c.
- Heart : Its
- Ventricles in some
  - One only, 145.
  - Two.
  - Three, as some think.

Situation nearer the midst of the body, than in man.

Want of the fastening of the pericardium to the midriff, 148.

Nervous kinds. A sample of which is given in the different correspondence between the head and heart of man and beast, by means of the nerves, 150.

Birds. Concerning which I take a view of their

Body and motion ; where I consider

The parts concerned in their motion, 155.

The shape of the body, made exactly for swimming in, and passing through the air.

Feathers, which are

Most exactly made for lightness and strength.

All well placed in every part, for the covering and motion of the body.

Preened and dressed, 156.

Wings, which are

Made of the very best materials ; viz. of bones, light and strong ; joints exactly opening, shutting, and moving, as the occasions of flight require ; and the pectoral muscles, of the greatest strength of any in the whole body.

Placed in the nicest point of the body of every species, according to the occasions of flight, swimming, or diving.

Tail, which is well made, and placed to keep the body steady, and assist in its ascents and descents, 160.

Legs and feet, which are made light for flight, and incomparably accouter'd for their proper occasions of

Swim-

- Swimming. 162.
- Walking.
- Catching prey.
- Roosting.
- Hanging.
- Wading and searching the waters.
- Lifting them upon their wings.
- Motion itself.
  - { Performed by the nicest laws of mechanics.
  - { Answering every purpose and occasion.
- Other parts of the body ; viz. the
  - { Head, remarkable for the commodious
    - { Shape of itself, 164.
    - { Forms of the bill.
    - { Site of the eye and ear.
    - { Position of the brain.
    - { Structure of the
      - { Larynx.
      - { Tongue.
      - { Inner ear.
    - { Provision by nerves in the bill for tast-  
ing and distinguishing food, 170.
  - { Stomachs, one to
    - { Macerate and prepare, 171.
    - { Grind and digest.
  - { Lungs, incomparably made for
    - { Respiration, 173.
    - { Making the body buoyant.
  - { Neck, which is made
    - { In due proportion to the legs.
    - { To search in the waters, and
    - { To counterpoise the body in flight.
- State. Of which I take notice of three things ; viz. their
  - { Migration remarkable for
    - { The knowledge birds have of
    - { Their times of passage,
    - { The places proper for them.
  - { Their accommodation for long flights, by  
long or else strong wings. lacu-

Incubation, which is considerable for

The egg, and its parts, 179.

Act itself; that these creatures should be-  
take themselves to it, know this to be the  
way to produce their young, and with  
delight and patience sit such a number of  
days.

The neglect of it in any, as the ostrich, and  
the wonderful provision for the youth in  
that case, 183

Nidification. Of which before.

Insects. Which although a despised tribe, doth in  
some respects more set forth infinite power and  
wisdom of the Creator, than the larger animals.

The things in this tribe remarked upon, are their  
Body, 189.

Shaped, not so much for long flights, as for  
their food, and condition of life.

Built not with bones, but with what serves  
both for bones and covering too.

Eyes, reticulated to see all ways at once,  
191.

Antennæ, and their use, 192.

Legs and feet made for

{ Creeping, 194.

{ Swimming and walking.

{ Hanging on smooth surfaces.

{ Leaping.

{ Digging.

{ Spinning and weaving webbs and cases.

Wings, which are

{ Nicely distended with bones, 198.

{ Some incomparably adorned with feathers  
and elegant colours.

{ Some jointed and folded up in their ely-  
tra, and distended again at pleasure.

{ In number either

{ Two, with poises.

{ Four, without poises.

{ Surprizing minuteness of some of those ani-  
mals

make themselves, especially of their parts, which are as numerous and various as in other animal bodies, 200.

{ State: which sets forth a particular concurrence of the divine providence, in the wise and careful provision that is made for their

{ Security against winter, by their

{ Substisting in a different, viz. their nymph or aurelia-state, 203.

{ Living in torpitude, without any waste of body or spirits, 204.

{ Laying up provisions before-hand.

{ Preservation of their species by their

{ Choosing proper places to lay up their eggs and sperm, so that the

{ Eggs may have due incubation, 208.

{ Young sufficient food.

{ Care and curiosity in repositing their eggs in proper order, and with the proper parts uppermost, 221.

{ Incomparable art of nidification, by being covered'd with

{ Parts proper for, and agreeable to the several ways of nidification, and the materials they use in it.

{ Architectonick sagacity to build and wove their cells, or to make even nature herself their hand-maid, 224.

Reptiles. Which agreeing with other animals in something or other before treated of, I confine only their

{ Motion, which is very remarkable, whether we consider the

{ Manner of it, as

{ Vermicular, 237.

{ Sinuous.

{ Snail-like.

{ Caterpillar-like.

{ Multipedous.

{ Parts ministering to it.

{ Poison, which serves to

{ Scourge man's wickedness, 243.

{ Their easy capture and mastery of their prey.

{ Their digestion.

{ Watery inhabitants considerable for their

{ Great variety, 246.

{ Prodigious multitudes.

{ Vast bulk of some, and surprising minuteness of others, 246.

{ Incomparable contrivance and structure of their bodies.

{ Supplies of food.

{ Respiration.

{ Adjustment of their organs of vision to their element.

{ Poise and motion of the body every way, 249.

{ Insensitive inhabitants. Among which having mentioned fossils, and others, I insist only upon vegetables, and that in a cursory manner upon their

{ Great variety for the several uses of the world, 250.

{ Anatomy.

{ Leaves, 254.

{ Flowers, and their admirable gaiety.

{ Seed, remarkable for its

{ Generation.

{ Make.

{ Containing in it a compleat plant, 256.

{ Preservation and safety in the gems, fruit, earth, &c.

{ Sowing, which is provided for by down, wings, springy cases, carried about by birds, sown by the husbandman, &c. 262.

{ Growing and standing : Some by

{ Their own strength, 270.

{ The help of others, by clasping about, or hanging upon them.

{ Remarkable use, especially of some which seem to be provided for the good of

All



{ All places, 274.

{ Some particular places, to

{ Heal some local distempers.

{ Supply some local wants.

Practical inferences upon the whole are these six; viz.  
That God's works

1. Are great and excellent, 280.
2. Ought to be enquired into, with a commendation of such as do so, 282.
3. Are manifest to all, and therefore Atheism unreasonable, 283.
4. Ought to excite fear and obedience, 287.
5. Ought to excite thankfulness, 289.
6. Should move us to pay God his due honours and worship, particularly that of the Lord's day: which is an appointment

{ The most ancient, 293.

{ Wisely contrived for dispatch of business, and to prevent carnality.

{ Whose proper business is, to cease from worldly, and to follow spiritual employments; the chief of which is the publick worship of God,





A

# SURVEY

OF THE

Terraqueous GLOBE.

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## INTRODUCTION.

IN *Psal.* cxi. 2. the Psalmist asserts, that  
'the (a) works of the Lord are great;  
'sought out of all them that have pleasure  
therein:' This is true of all God's works,  
particularly of his works of creation: which,  
when

(a) It is not unlikely that the Psalmist might  
mean, at least have an eye to, the works of the cre-  
ation in this text, the word *מְעַשָּׂיוֹ* being the same  
as in *Psal.* xix. 1. is translated *God's handy work*,  
which is manifestly applied to the works of the Crea-  
tion, and properly signifieth *factum, opus, opificium*,  
from *עָשָׂה* *fecit, paravit, aptavit*. And, saith Kircher,  
*significat talem affectionem, quâ aliquid existit vel  
realiter, vel ornatè, vel ut non sit in pristino statu  
quo fuit.* *Concord. p. 2. col. 931.*

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B

when sought out; or, as the Hebrew word (b) signifieth, when ‘heedfully and deeply pried into, sollicitously observed and enquired out,’ especially when clearly discovered to us; in this case, I say, we find those works of God abundantly to deserve the Psalmist’s character of being Great and Noble; inasmuch as they are made with the most exquisite art, (c) contrived with the utmost sagacity, and order’d with

(b) קָרַח ‘Quæsit, perquisivit, sciscitatus est.’ *Buxtor. in verb.* ‘Et simul importat curam, & solitudinem.’ *Conrad. Kircb. ibid. p. 1. col. 1174.*

(c) ‘Quod si omnes mundi partes ita constitutæ sunt, ut neque ad usum meliores potuerint esse, neque ad speciem pulchriores; videamus utrùm ea fortuita sint, an eo statu, quo coherere nullo modo potuerint, nisi sensu moderante divinæque providentiâ. Si ergo meliora sunt ea quæ Naturâ, quàm illa, quæ arte perfectæ sunt, nec an efficit quid sine ratione; ne natura quidem rationis experts est habenda. Quis igitur convenit, signum, aut tabulam pictam cum adspexeris, scire adhibitam esse artem; cumque procul cursum navigii videris, non dubitare, quin id ratione atque arte moveatur: aut cum solarium, &c. Mundum autem, qui & has ipsas artes, & earum artifices, & cuncta complectatur, consilii & rationis esse expertem putare? Quod si in Scythiam, aut in Britanniam, spheram aliquis tulerit hanc, quam nuper familiaris noster effecit Posidonius, cujus singulæ conversiones idem efficiunt in sole, &c.-----quod efficitur in cœlo singulis diebus & noctibus; quis illâ barbarie dubitet, quin ea sphaera sit perfectæ ratione? Hi autem dubitant de mundo, ex quo oriuntur, & fiunt omnia, casu ne ipse sit effectus,-----’

with a plain wise design, and ministring to admirable ends (*d*). For which reason St. *Paul* might well affirm of those *Ποιήματα* of God, That the 'invisible things of God, even his eternal power and godhead, are understood by them.' And indeed they are the most easy and intelligible demonstrations of the Being and Attributes of God; (*e*) especially to such as are unacquainted with the subtilties of reasoning and argumentation; as the greatest part of mankind are.

It may not therefore be unsuitable to the nature and design of lectures (*f*), founded by one of the greatest virtuoso's of the last age, and instituted too on purpose for the proof of the christian religion against atheists, and other infidels, to improve this occasion in the demonstration

an ratione, an mente divina? Et Archimедem arbitrantur plus valuisse in imitandis sphaerae conversionibus, quam naturam in efficiendis, praesertim cum multis partibus sint illa perfecta, quam haec simulata, solertius, &c. *Cic. de nat. l. 2. c. 34, 35.*

(*d*) And a little before he saith of nature itself, Omnem ergo regit naturam ipse [*Deus*] &c.

(*e*) 'Mundus codex est dei, in quo jugiter legere debemus.' *Bernard. serm.*

'Arbitror nullam gentem, neque hominum societatem, apud quos ulla deorum est religio, quidquam habere sacris Eleusiniis aut Samothraciis simile: Ea tamen obscure docent quae profitentur: Naturae vero opera in omnibus animantibus sunt perspicua.' *Galen. de us. part. l. 17. c. 1.*

(*f*) 'Philosophia est catechismus ad fidem.' *Cy. il. 1. contr. Jul.*

stration of the Being and Attributes of an infinitely wise and powerful Creator, from a cursory survey of the works of creation, or (as often called) of nature.

Which works belong either to our terrestrial globe, or the heavens.

I shall begin with our own globe, being nearest, and falling most under our senses: Which being a subject very various and copious, for the more methodical and orderly proceeding upon it, I shall distribute the works therein,

I. Into such as are not properly parts, but appendages or outworks of the globe.

II. The Globe itself.



## BOOK I.

*Of the out-works of the terraqueous  
Globe; the Atmosphere, Light, and  
Gravity.*

## CHAP. I.

*Of the Atmosphere in general.*

THE Atmosphere, or mass of air, vapours and clouds, which surrounds our globe, will appear to be a matter of design, and the infinitely wise Creator's work, if we consider its nature and make (a), and its use to the world (b).

1. Its nature and make, a mass of air, of subtile penetrating matter, fit to pervade other bodies, to penetrate into the inmost recesses of nature, to excite, animate, and spiritualize, and, in short, to be the very soul of this lower world. A thing consequently,

2. Of greatest use to the world, useful to the life, the health, the comfort, the pleasure, and business of the whole globe. It is the air the whole

(a) 'Mundi pars est aër, & quidem necessaria :  
'Hic est enim qui cœlum terramque connectit.'  
*Senec. nat. qu. l. 2. c. 4.*

(b) Ipse aër nobiscum videt, nobiscum audit, nobiscum sonat ; nihil enim eorum sine eo fieri potest, &c. *Cic. de nat. deor. l. 2, c. 33.*



whole animal world breatheth, and liveth by ;  
not only the animals inhabiting the earth (c) and  
air

(c) As the air is of absolute necessity to animal life, so it is necessary that it should be of a due temperament or consistence ; not foul, by reason that suffocateth ; not too rare and thin, because that sufficeth not : with examples of each of which, I shall a little entertain the reader. In one of Mr. *Hawkebee's* compressing engines, I closely shut up a Sparrow, without forcing any air in ; and in less than an hour the bird began to pant, and be concerned ; and in less than an hour and half to be sick, vomit, and more out of breath ; and in two hours time was nearly expiring.

Another I put in and compressed the air, but the engine leaking, I frequently renewed the compression ; by which means (although the bird panted a little after the first hour) yet after such frequent compressures, and immision of fresh air, it was very little concerned, and taken out seemingly unhurt after three hours.

After this I made two other experiments in compressed air, with the weight of two atmospheres injected, the engine holding tight and well ; the one with the Great Titmouse, the other with a Sparrow. For near an hour they seemed but little concerned ; but after that grew fainter, and in two hours time sick, and in three hours time died. Another thing I took notice of, was, that when the birds were sick, and very restless, I fancied they were somewhat relieved for a short space, with the motion of the air, caused by their fluttering and shaking their wings (a thing worth trying in the diving-bell.) I shall leave the ingenious reader to judge what the cause was of both the birds living longer in compressed

by ; in uncompressed air ; whether a less quantity of  
(-) and was not sooner fouled and render'd unfit for re-  
air ration, than a greater.

From these experiments two things are mani-  
fested ; one is, that air, in some measure compres-  
sed, or rather heavy, is necessary to animal life: of  
which by and by. The other, that fresh air is also  
necessary ; for pent-up air, when overcharged with  
the vapours emitted out of the animal's body, be-  
comes unfit for respiration. For which reason, in  
the diving-bell, after some time of stay under water,  
they are forced to come up and take in fresh air, or  
by some such means recruit it. But the famous *Cor-  
neilius Drebell* contrived not only a vessel to be rowed  
under water, but also a liquor to be carried in that  
vessel, that would supply the want of fresh air. The  
vessel was made for King *James I.* It carried twelve  
rowers, besides the passengers. It was tried in the  
river of *Thames*, and one of the persons that was in  
that submarine navigation was then alive, and told  
one, who related the matter to our famous founder,  
the honourable and most ingenious Mr. *Boyle*. As  
to the liquor, Mr. *Boyle* saith, he discovered by a  
doctor of physick, who married *Drebell's* daughter,  
that it was used from time to time, when the air,  
in the submarine boat, was clogged by the breath of  
the company, and thereby made unfit for respira-  
tion ; at which time, by unstopping a vessel full of  
this liquor, he could speedily restore to the troubled  
such a proportion of vital parts, as would make  
again for a good while fit for respiration. The se-  
cret of this liquor *Drebell* would never disclose to  
above one person, who himself assured Mr. *Boyle*  
that it was. *Vide Boyle's exp. phys. mecb. of the  
spring of the air, exp. 41.* in the digression. This story  
I have related from Mr. *Boyle*, but at the same time  
much

much question, whether the virtues of the liquors were so effectual as reported.

And as too gross, so too rare an air is unfit for respiration. Not to mention the forced rarefaction made by the air-pump, in the following note; it is found, that even the extraordinary natural rarefactions, upon the tops of very high hills, much affect respiration. An ecclesiastical person, who had visited the high mountains of *Armenia* (on which some fancy the ark rested) told Mr. *Boyle*, that whilst he was on the upper part of them, he was forced to fetch his breath oftner than he was wont: And taking notice of it when he came down, the people told him, that it was what happened to them when they were so high above the plane, and that it was a common observation among them. The like observation the same ecclesiastick made upon the top of a mountain in the *Cevennes*. So a learned traveller and curious person, on one of the highest ridges of the *Pyrenees*, called *Pic de midi*, found the air not so fit for respiration, as the common air, but he and his company were fain to breath shorter and oftner than the lower air. *Vide phil. transact.* No 63. or *Leibniz's abridg.* vol. II. p. 226.

Such another relation the learned *Joseph Addison* gives of himself, and his company, that, when they passed the high mountains of *Peru*, which they call *Periataca* (to which he saith, 'the *Alps* themselves seemed to them but as ordinary houses, in regard of high towers) he, and his companions, were furnished with such extreme pangs of straining and vomiting (not without casting up of blood too) and with so violent a distemper, that he concludes they should undoubtedly have died, but that this lasted not above three or four hours, before they came into a more convenient and natural temperance.

air (*d*), but those of the waters (*e*) too. Without it

of the air.' All which he concludes, proceeded from the too great subtilty and delicacy of the air, which is not proportionable to human respiration, which requires a more gross and temperate air. Vide *Boyle*, ubi supra.

Thus it appears, that an air too subtile, rare and light, is unfit for respiration: But the cause is not the subtilty, or too great delicacy, as Mr. *Boyle* thinks, but the too great lightness thereof, which renders it unable to be a counterbalance or an antagonist to the heart, and all the muscles ministering to respiration, and the diastole of the heart. Of which see book iv. chap. 7. note 1.

And as our inability to live in too rare and light an air, may discourage those vain attempts of flying, and whimsies of passing to the moon, &c. so our being able to bear an heavier state of the air is an excellent provision for mens occasions in mines, and other great depths of the earth; and those other greater pressures made upon the air, in the diving-bell, when we descend into great depths of the waters.

(*d*) That the inhabitants of the air (birds and insects) need the air as well as man, and other animals, is manifest from their speedy dying in too feculent, or too much rarified air; of which see the preceeding and following note (*f*). But yet birds and insects (some birds at least) can live in rarer air than man. Thus Eagles, Kites, Herons, and divers other birds, that delight in high flights, are not affected with the rarity of the medium, as those persons were in the preceeding note. So insects bear the air-pump well, as in the following note (*f*).

(*e*) Creatures inhabiting the waters need the air, well as other animals, yea, and fresh air too.

The

it most animals live scarce half a minute (✓); and others, that are the most accustomed to the want of it, live not without it many days.

And

The Hydrocanthari of all sorts, the Nymphæ of gnats, and many other water-insects, have a singular faculty, and an admirable apparatus, to raise their back-parts to the top of the waters, and take in fresh air. It is pretty to see, for instance, the Hydrocanthari come and thrust their tails out of the water, and take in a bubble of air, at the tip of their Vaginæ and tails, and then nimbly carry it down with them into the waters; and, when that is spent, or fouled, to ascend again and recruit it.

So fishes also are well known to use respiration, by passing the water through their mouths and gills. But Carps will live out of the water, only in the air; as is manifest by the experiment of their way of fattening them in *Holland*, and which hath been practised here in *England*; viz. they hang them up in a cellar, or some cool place, in wet moss in a small net, with their heads out, and feed them with white bread soaked in milk, for many days. This was told me by a person very curious, and of great honour and eminence, whose word (if I had leave to name him) no body would question: And it being an instance of the respiration of fishes very singular, and somewhat out of the way, I have for the reader's diversion taken notice of it.

(✓) By experiments I made myself in the air pump, in *September* and *October*, 1704, I observed that animals whose hearts have two ventricles, and no Foramen Ovale, as birds, dogs, cats, rats, mice, &c. die in less than half a minute, counting from the very first exsuction; especially in a small receiver.

And not only animals themselves, but even trees and plants, and the whole vegetable race, owe their vegetation and life to this useful element ; as will appear when I come to speak of them, and is manifest from their glory and verdure

A Mole (which I suspected might have born more than other quadrupeds) died in one minute (without recovery) in a large receiver ; and doubtless would hardly have survived half a minute in a small receiver. A Bat (although wounded) sustained the pump two minutes, and revived upon the re-admission of the air. After that, he remained four minutes and a half, and revived. Lastly, after he had been five minutes, he continued gasping for a time, and after twenty minutes I re-admitted the air, but the Bat never revived.

As for Insects ; Wasps, Bees, Hornets, Grasshoppers, and Lady-cows seemed dead in appearance in two minutes, but revived in the open air in two or three hours time, notwithstanding they had been in vacuo twenty-four hours.

The Ear-wig, the great Staphylinus, the great black lowfy Beetle, and some other insects, would seem unconcerned at the Vacuum a good while, and as dead ; but revive in the air, although some had lain sixteen hours in the exhausted receiver.

Snails bear the air-pump prodigiously, especially those in shells ; two of which lay above twenty-four hours, and seemed not much affected. The same snails I left in twenty-eight hours more after a second exhaustion, and found one of them quite dead, but the other revived.

Frogs and Toads bear the pump long, especially the former. A large toad, found in the house, died recoverable in less than six hours. Another toad  
and



verdure in a free air, and their becoming pale and sickly, and languishing and dying, when by any means excluded from it (e).

Thus useful, thus necessary, is the air to the life of the animated creatures; and no less is it

and frog I put in together, and the toad was seemingly dead in two hours, but the frog just alive. After they had remained there eleven hours, and seemingly dead, the frog recovered in the open air, only weak, but the toad was quite dead. The same frog being put in again for twenty-seven hours, then quite died.

The animalcules in Pepper-water remained in vacuo twenty-four hours. And after they had been exposed a day or two to the open air, I found some of them dead, some alive.

(g) That the air is the principal cause of the vegetation of plants, *Borelli* proves, in his excellent book *De mot. animal.* Vol. II. prop. 181. And in the next proposition, he assureth, 'In plantis quæque peragi aëris respirationem quandam imperfectam, à quâ earum vita pendet, & conservatur.' But of this more, when I come to survey vegetables.

'Some Lettice-seed being sown upon some earth in the open air, and some of the same seed, at the same time, upon other earth, in the glass-receiver of the pneumatick engine, afterwards exhausted of air; the seed exposed to the air, was grown up an inch and half high within eight days; but that in the exhausted receiver not at all. And air being again admitted into the same emptied receiver, to see whether any of the seed would then come up, it was found, that in the space of one week it was grown up to the height of two or three inches.' *Vide Phil. Transf. No 23. Lowth. abridg. Vol. II. p. 206.*

to the motion and conveyance of many of them. All the winged tribes owe their flight and buoyancy (*b*) to it, as shall be shewn in a proper place: And even the watry inhabitants themselves cannot ascend and descend into their element, well without it (*i*). But

(*b*) ‘ In volucris pulmones perforati aërem inspiratum in totam ventris cavitatem admittunt: Hujus ratio, ut propter corporis truncum aëre repletum & quasi extensum, ipsa magis volatilia evadant, faciliusque ab aëre externo, propter intimi penum, sustententur. Equidem pisces, quò leviùs in aquis natent, in abdomine vesicas aëre inflatas gestant: Pariter & volucres, propter corporis truncum aëre impletum & quasi inflatum, nudo aëri incumbentes, minus gravantur, proindeque leviùs & expeditiùs volant.’ *Willis de anim. brut. p. 1. c. 3.*

(*i*) ‘ Fishes, by reason of the bladder of air within them, can sustain, or keep themselves in any depth of water: For the air in that bladder being more or less compressed, according to the depth the fish swims at, takes up more or less space; and consequently, the body of the fish, part of whose bulk this bladder is, is greater or less, according to the several depths, and yet retains the same weight. Now the rule *de insidentibus humido* is, that a body, that is heavier than so much water as is equal in quantity to the bulk of it, will sink; a body that is lighter will swim; a body of equal weight will rest in any part of the water. By this rule, if the fish, in the middle region of the water, be of equal weight to the water, that is, commensurate to the bulk of it, the fish will rest there, without any tendency upwards or downwards: And, if the fish be deeper in the water, the bulk of the fish be-

But it would be tedious to descend too far into particulars, to reckon up the many benefits

\* coming less by the compression of the bladder, and  
 \* yet retaining the same weight, it will sink, and rest  
 \* at the bottom. And on the other side, if the fish  
 \* be higher than the middle region, the air dilating  
 \* itself, and the bulk of the fish consequently in-  
 \* creasing, but not the weight, the fish will rise up-  
 \* wards, and rest at the top of the water. Perhaps,  
 \* the fish by some action can emit air out of its blad-  
 \* der ;-----and, when not enough, take in air,-----  
 \* and then it will not be wondered, that there should  
 \* be always a fit proportion of air in all fishes to serve  
 \* their use, &c.' Then follows a method of Mr.  
*Boyle's* to experiment the truth of this. After which,  
 in Mr. *Lowthorp's* Abridgment, follow Mr. *Ray's*  
 observations. 'I think that-----hath hit upon the  
 \* true use of the swimming bladders in fishes. For,  
 \* 1. It hath been observed, that if the swimming-  
 \* bladder of any fish be pricked or broken, such  
 \* a fish sinks presently to the bottom, and can  
 \* neither support or raise itself up in the water.  
 \* 2. Flat fishes, as Soles, Plaise, &c. which lie al-  
 \* ways groveling at the bottom, have no swimming-  
 \* bladders that ever I could find. 3. In most fishes  
 \* there is a manifest channel leading from the gul-  
 \* let----to the said bladder, which, without doubt,  
 \* serves for the conveying air thereunto,-----In the  
 \* coat of this bladder is a musculous power to con-  
 \* tract it when the fish lifts.' See more very cu-  
 rious observations relating to this matter, of the late  
 great Mr. *Ray*, as also of the curious anonymous  
 gentleman, in the ingenious Mr. *Lowthorp's* abridg-  
 ment before cited, p. 845. from *Philosoph. Trans.*  
 No 114, 115.

fits of this noble appendage of our globe in many useful engines (*k*); in many of the functions and operations of nature (*l*), in the conveyance

(*k*) Among the engines in which the air is useful, pumps may be accounted not contemptible ones, and divers other hydraulical engines, which need not be particularly insisted on. In these the water was imagined to raise by the power of suction, to avoid a vacuum, and such unintelligible stuff; but the justly famous Mr. Boyle was the first that solved these phenomena by the weight of the atmosphere. His ingenious and curious observations and experiments relating hereto, may be seen in his little tract, 'Of the cause of attraction by suction,' and divers others of his tracts.

(*l*) It would be endless to specify the uses of the air in nature's operations: I shall therefore, for a sample only, name its great use to the world in conserving animated bodies, whether endowed with animal or vegetative life, and its contrary quality of dissolving other bodies; by which means many bodies that would prove nuisances to the world, are put out of the way, by being reduced into their first principles (as we say) and so embodied with the earth again. Of its faculty as a menstruum, or its power to dissolve bodies, I may instance in crystal glasses; which, with long keeping, especially if not used, will in time be reduced to a powder, as I have seen. So divers minerals, earth, stones, fossil-shells, woods, &c. which from Noab's flood, at least for many ages, have lain under ground, so secure from corruption, that, on the contrary, they have been thereby made much the stronger, have in the open air soon moulder'd away. Of which last Mr. Boyle gives an instance (from the Dissertation *de admirandis*

veyance of sounds; and a thousand things besides. And I shall but just mention the admirable use of our atmosphere in ministering to the enlightning of the world, by its reflecting the light of the heavenly bodies to us (*m*); and refracting the sun-beams to our eye, before it  
ever

*Hungar. aquis*) of a great oak, like a huge beam dug out of a salt-mine in *Transilvania*, 'so hard, that it 'would not easily be wrought upon by iron tools; 'yet, being exposed to the air out of the mines, it 'became so rotten, that in four days it was easy to 'be broken, and crumbled between one's fingers.' Boyle's suspic. about some hidden qualities in the air, p. 28. So the trees turned out of the earth by the breaches at *West-Thurrock* and *Dagenham*, near me, although probably no other than Alder, and interred many ages ago in a rotten oazy mould, were so exceedingly tough, hard, and sound at first, that I could make but little impressions on them with the strokes of an axe; but being exposed to the air and water, soon became so rotten as to be crumbled between the fingers. See my observations in *Philos. Transact.* No 335.

(*m*) By reflecting the light of the heavenly bodies to us, I mean that whiteness or lightness which is in the air in the day-time, caused by the rays of light striking upon the particles of the atmosphere, as well as upon the clouds above, and the other objects beneath upon the earth. To the same cause also we owe the twilight; *viz.* to the sun-beams touching the uppermost particles of our atmosphere, which they do when the sun is about eighteen degrees beneath the horizon. And as the beams reach more and more of the airy particles, so darkness

goes

ever surmounteth our horizon (*n*) ; by which means the day is protracted throughout the whole globe ; and the long and dismal nights are

goes off, and day-light comes on and increaseth. For an exemplification of this, the experiment may serve of transmitting a few rays of the sun through a small hole into a dark room : By which means the rays which meet with dust, and other particles flying in the air, are render'd visible ; or (which amounts to the same) those swimming small bodies are render'd visible, by their reflecting the light of the sun-beams to the eye, which, without such reflection, would itself be invisible.

The azure colour of the sky, Sir *Isaac Newton* attributes to vapours beginning to condense, and that are not able to reflect the other colours. *Vid. Optic. l. 2. Par. 3. Prop. 7.*

(*n*) By the refractive power of the air, the sun, and the other heavenly bodies seem higher than really they are, especially near the horizon. What the refractions amount unto, what variations they have, and what alterations in time they cause, may be briefly seen in a little book call'd *The Artificial Clock-maker*. Chap. II.

‘ Although this inflective quality of the air be a great incumbrance and confusion of astronomical observations ; ---- yet it is not without some considerable benefit to navigation ; and indeed, in some cases, the benefit thereby obtained is much greater than would be the benefit of having the ray proceed in an exact straight line.’ [Then he mentions the benefit hereof to the polar parts of the world.] ‘ But this by the by (saith he.) The great advantage I consider therein, is the first discovery



are shorten'd in the frigid zones, and day sooner approacheth them; yea, the sun itself riseth in appearance (when really it is absent from them) to the great comfort of those forlorn places (o).

But

‘ of land upon the sea; for by means hereof, the  
 ‘ tops of hills and lands are raised up into the air,  
 ‘ so as to be discoverable several leagues farther off  
 ‘ on the sea than they would be, were there no such  
 ‘ refraction, which is of great benefit to navigation  
 ‘ for steering their course in the night, when they  
 ‘ approach near land; and likewise for directing  
 ‘ them in the day-time, much more certainly than  
 ‘ the most exact celestial observations could do by  
 ‘ the help of an uninflected ray, especially in such  
 ‘ places as they have no soundings.’ [Then he pro-  
 poses a method to find, by these means, the distance  
 of objects at sea.] *Vide Dr. Hook's Post. Works. Lett.*  
*of Navig. p. 466.*

(o) ‘ Cum Belgæ in Novâ Zemblâ hybernarent, fol-  
 ‘ illis apparuit 16 diebus citiùs quàm revera in ho-  
 ‘ rizonte existeret, hoc est, cùm adhuc infra hori-  
 ‘ zontem depressus esset quatuor circiter gradibus, &  
 ‘ quidem aëre sereno.’ *Varen. Geog. c. 19. Prop. 22.*

[These Hollanders] ‘ found, that the night in  
 ‘ that place shortened no less than a whole month;  
 ‘ which must needs be a very great comfort to all  
 ‘ such places as lie very far towards the north and  
 ‘ south poles, where length of night, and want of  
 ‘ seeing the sun, cannot chuse but be very tedious and  
 ‘ irksome.’ *Hook, ibid.*

[By means of the refractions] ‘ we found the sun  
 ‘ to rise twenty minutes before it should; and in  
 ‘ the evening to remain above the horizon twenty  
 ‘ minutes (or thereabouts) longer than it should.’  
*Capt. James's Journ. in Boyle of cold. Tit. 18. p. 190.*

But passing by all these things with only a bare mention, and wholly omitting others that might have been named, I shall only insist upon the excellent use of this noble circumambient companion of our globe, in respect of two of its meteors, the winds, and the clouds and rain (p).

CH A P. II.

*Of the WINDS. (a)*

**T**O pass by other considerations, whereby I might demonstrate the winds to be the infinite Creator's contrivance, I shall insist only upon their great usefulness to the world. And so

(p) 'Aër in nubes cogitur, humoremque colligens terram auget imbribus : tum effluens huc & illuc, ventos efficit. Idem annuas frigorū & calorum facit varietates : idemque & volatus alitum sustinet, & spiritu ductus alit & sustentat animantes.' Cic. de nat. deor. l. 2. c. 39.

(a) 'Ventus est aër fluens,' is Seneca's definition. Na. Qu. l. 5. And as wind is a current of the air, so that which excites or alters its currents, may be justly said to be the cause of the winds. An æquipoise of the atmosphere produceth a calm ; but if that æquipoise be more or less taken off, a stream of air, or wind, is thereby accordingly produced either stronger or weaker, swifter or slower. And divers things there are that may make such alterations in the æquipoise or balance of the atmosphere ; viz. eruptions

so great is their use, and of such absolute necessity are they to the salubrity of the atmosphere, that all the world would be poisoned without those agitations thereof. We find how putrid, fetid, and unfit for respiration, as well as health

eruptions of vapours from sea or land; rarifications and condensations in one place more than another; the falling of rain, pressure of the clouds, &c. *Pliny*, l. 2. c. 45. tells us of a certain cavern in *Dalmatia*, call'd *Santa*, 'in quem (saith he) dejecto levi pondere, quamvis tranquillo die, turbini similis emicat procella.' But as to caves it is observed, that they often emit winds more or less. *Dr. Connor*, taking notice of this matter, specifies these, 'in regno Neapolitano ex immani Cumanæ Sibyllæ antro tenuem ventum effluentem percepi.' The like he observed at the caves at *Baja*, and in some of the mines of *Germany*, and in the large salt-mines of *Cracow* in *Poland*. 'Ubi (saith he) opifices, & ipsæ fodinæ dominus Andreas Morstin, Nob. Polonus, mihi asseruerunt, quòd tanta aliquando ventorum tempestas ex ambagiosis hujus fodinæ recessibus surgere solebat, quòd laborantes fossiores humi prosternebat, nec non portas & domicilia (quæ sibi in hac fodinâ artifices exstruunt) penitus evertebat.' *Bern. Connor. differ. med. phys. p. 33. artic. 3.*

And as great caves, so great lakes sometimes send forth winds. So *Gassendus* saith the *Lacus Lemanoth*, 'E quo dum exoritur fumus, nubes haud dubie creanda est, quæ sit brevi in tempestatem fissimam exoneranda.' *Gassend. vit. Peiresk. l. 5. p. 417.*

But the most universal and constant alterations of the balance of the atmosphere, are from heat and cold.

and pleasure, a stagnating, confined, pent up  
 air is. And if the whole mass of air and va-  
 pours was always at rest, and without motion,  
 instead of refreshing and animating, it would  
 suffocate and poison all the world: But the  
 perpetual

old. This is manifest in the general trade winds,  
 blowing all the year between the tropicks from east  
 to west: If the cause thereof be (as some ingenious  
 men imagine) the sun's daily progress round that  
 part of the globe, and by his heat rarifying one part  
 of the air, whilst the cooler and heavier air behind  
 presseth after. So the sea and land breezes in note (*d.*)  
 and so in our climate, the northerly and southerly  
 winds (commonly esteemed the causes of cold and  
 warm weather) are really the effects of the cold or  
 warmth of the atmosphere: Of which I have had so  
 many confirmations, that I have no doubt of it. As  
 for instance, it is not uncommon to see a warm  
 southerly wind, suddenly changed to the north, by  
 the fall of snow or hail; to see the wind in a frosty,  
 cold morning, north, and when the sun hath well  
 warmed the earth and air, you may observe it to  
 wheel about towards the southerly quarters, and  
 again to turn northerly or easterly in the cold eve-  
 ning. It is from hence also, that in thunder-showers  
 the wind and clouds are oftentimes contrary to one  
 another (especially if hail falls) the sultry weather  
 now directing the wind one way, and the cold  
 above the clouds another way. I took notice upon  
 March the 10th, 1710-11. (and divers such like  
 instances I have had before and since) that the morn-  
 ing was warm, and what wind stirred was west-  
 north-west, but the clouds were thick and black (as  
 generally they are when snow ensues.) A little be-  
 fore

perpetual commotions it receives from the gales and storms, keep it pure and healthful (b).

Neither

fore noon the wind veered about to north by west and sometimes to other points, the clouds at the same time flying some north by west, some south west: About one of the clock it rained apace, the clouds flying sometimes north-east, then north, and at last both wind and clouds settled north by west at which time sleet fell plentifully, and it grew very cold. From all which I observe, 1. That although our region below was warm, the region of the clouds was cold, as the black snowy clouds shewed. 2. That the struggle between the warmth of our air and the cold of the cloudy region, stopped the air currents of both regions. 3. That the falling of the snow thro' our warmer air, melted into rain at first but that it became sleet, after the superior cold had conquered the inferior warmth. 4. That, as the cold prevailed by degrees, so by degrees it wheeled about both the winds and clouds from the northwards towards the south.

‘ Hippocrates, l. 2. de vict. orat. Omnes venti vel à nive, glacie, vehementi gelu, fluminibus, & spirare necesse judicat.’ *Bartolin. de usu nivis, c. 1.*

(b) ‘ It is well observed in my Lord Howard’s voyage to *Constantinople*, that at *Vienna* they have frequent winds, which if they cease long in summer, the plague often ensues: So that it is now grown into a proverb, that if *Austria* be not windy it is subject to contagion.’ *Bohun of winds, p. 21.*

From some such commotions of the air I imagine it is, that at *Grand Cairo* the plague immediately ceases, as soon as the *Nile* begins to overflow; though Mr. *Boyle* attributes it to nitrous corpuscles. *Determ. nat. of effluv. chap. 4.*

Neither are those ventilations beneficial only to the health, but to the pleasure also of the inhabitants of the terraqueous globe; witness the gales which fan us in the heat of summer; without which, even in this our temperate zone, men are scarce able to perform the labours of their calling, or not without danger of health and life (c). But especially, witness the

‘Nulla enim propemodum regio est, quæ non habeat aliquem flatum ex se nascentem, & circa se cadentem.’

‘Inter cætera itaque providentiæ opera, hoc quoque aliquis, ut dignum admiratione, suspexerit. Non enim ex unâ causâ ventos aut invenit, aut per diversa disposuit: sed primum ut aëra non sinerent pigrescere, sed assiduâ vexatione utilem redderent, vitalemque tracturis.’ *Sen. nat. quæst.* 5. c. 17, 18.

All this is more evident, from the cause assign’d to malignant epidemical diseases, particularly the plague, by my ingenious, learned friend, Dr. Mead; and that is, an hot and moist temperament of the air, which is observed by *Hippocrates*, *Galen*, and the general histories of epidemical diseases, to attend those distempers. *Vide Mead of poisons, essay 5. p. 161.* But indeed, whether the cause be this, or poisonous, malignant exhalations, or animalcules, as others think, the winds are however very salutiferous in such cases, in cooling the air, and dispersing and driving away the moist or pestiferous vapours.

(c) July 8. 1707. (called for some time after the Hot Tuesday) was so excessively hot and suffocating, by reason there was no wind stirring, that divers persons died, or were in great danger of death, in their harvest-



the perpetual gales which throughout the whole year do fan the torrid zone, and make that climate an healthful and pleasant habitation, which would otherwise be scarce habitable.

harvest-work. Particularly one who had formerly been my servant, a healthy, lusty, young man, was killed by the heat; and several horses on the road dropped down, and died the same day.

In the foregoing notes, having taken notice of some things relating to heat, although it be somewhat out of the way, I hope the reader will excuse me, if I entertain him with some observations I made about the heat of the air under the line, compared with the heat of our bodies. *J. Patrick*, who, as he is very accurate in making barometrical and thermometrical instruments, had the curiosity, for the nicer adjusting his thermometers, to send two abroad (under the care of two very sensible ingenious men) one to the northern lat. of 81; the other to the parts under the equinoctial: In these two different climates, the places were marked where the spirits stood at the severest cold and greatest heat. And according to these observations he graduates his thermometers. With his standard I compared my standard thermometers, from all the degrees of cold I could make with Sal Armoniac, &c. to the greatest degrees of heat our thermometers would reach to. And with the same thermometer (of mine) I experimented the greatest heat of my body, in *July*, 1709, first in an hot day without exercise, by putting the ball of my thermometer under my arm-pits, and other hottest parts of my body: By which means the spirits were raised 284 tenths of an inch above the ball. After that in a much hotter day, and in-

deed

To these I might add many other great conveniencies of the winds in various engines, and various businesses. I might particularly insist upon its great use to transport men to the farthest distant regions of the world; (d) and I might

deed nearly as hot as any day with us; and after I had heated myself with strong exercise too, as much as I could well bear, I again tried the same experiment, but could not get the spirits above 288 tenths; which I thought an inconsiderable difference for so seemingly a very different heat of my body. But from some experiments I have made (although I have unfortunately forgotten them) in very cold weather, I imagine the heat of an healthy body to be always much the same in the warmest parts thereof, both in summer and winter. Now between those very degrees of 284, and 288, the point of the equatorial heat falleth. From which observation it appears, that there is pretty nearly an equal contemperament of the warmth of our bodies, to that of the hottest part of the atmosphere inhabited by us.

If the proportion of the degrees of heat be desired from the freezing-point, to the winter, spring, and summer-air, the heat of man's body, of heated water, melted metals, and so to actual fire; an account may be met with of it, by my most ingenious friend, the great Sir *Isaac Newton*, in *Phil. Transact.* No 270.

(d) 'In hoc Providentia ac dispositor ille mundi Deus, aëra ventis exercendum dedit,-----non ut nos classes partem freti occupaturas compleremus milite armato, &c. Dedit ille ventos ad custodiendam cœli terrarumque temperiem, ad evocandas suppressendasque aquas, ad alendos fatorum atque arborum fructus; quos ad maturitatem cum aliis

might particularly speak of the general and coasting trade-winds, the sea, and the land-breezes; (e) the one serving to carry the mariner in long voyages from east to west; the other serving to waft him to particular places; the

‘causis adducit ipsa jactatio, attrahens cibum in summa, & ne torpeat, promovens. Dedit ventos ad ulteriora noscenda; fuisset enim imperitum animal, & sine magnâ experientiâ rerum homo, si circumscriberetur natalis solî sine. Dedit ventos ut commoda cujusque regionis fierent communia; non ut legiones equitemque gestarent, nec ut perniciosa gentibus arma transveherent.’ *Seneca, ibid.*

(e) ‘Sea-breezes commonly rise in the morning about nine o’ clock.-----They first approach the shore gently, as if they were afraid to come near it.-----It comes in a fine, small, black curl upon the water, whereas all the sea between it and the shore (not yet reached by it) is as smooth and even as glass in comparison. In half an hour’s time after it has reached the shore, it fans pretty briskly, and so increaseth gradually till twelve o’ clock; then it is commonly the strongest, and lasts so till two or three, a very brisk gale.-----After three it begins to die away again, and gradually withdraws its force till all is spent; and about five o’ clock---it is lulled asleep, and comes no more till next morning.

‘And as the Sea-breezes do blow in the day, and rest in the night; so on the contrary [the land-breezes] blow in the night, and rest in the day, alternately succeeding each other-----They spring up between six and twelve at night, and last till six, eight or ten in the morning.’ *Dampier’s diss. of winds. Chap. 4.*

the one serving to carry him into his harbour, the other to bring him out. But I should go too far to take notice of all particulars (*f*). Leaving therefore the winds, I proceed, in the next place, to the clouds and rain.

(*f*) One thing more I believe some of my friends will expect from me is, that I shew the result of comparing my own observations of the winds, with others they know I have from *Ireland, Switserland, Italy, France, New-England*, and some of our parts of *England*. But the observations being, some of them, but of one year, and most of the rest of but a few years, I have not been able to determine any great matters. The chief of what I have observed is, that the winds in all these places seldom agree; but when they most certainly do so, it is commonly when the winds are strong, and of long continuance in the same quarter: And more, I think, in the northerly and easterly, than other points. Also, a strong wind in one place, is oftentimes a weak one in another place, or moderate, according as places have been nearer or farther distant. *Vide Philos. Transact.* No 297, and 321. But to give a good and tolerable account of this, or any other of the weather, it is necessary to have good histories thereof from all parts; which as yet we have but few of, and they imperfect, for want of longer and sufficient observations.



## C H A P. III.

*Of the Clouds and Rain.*

**T**HE clouds and rain (*a*) we shall find to be no less useful meteors than the last mentioned, as is manifest in the refreshing pleasant shades which the clouds afford, and the fertile dews and showers which they pour down on

(*a*) Clouds and rain are made of vapours raised from water, or moisture only. So that I utterly exclude the notion of dry, terrene exhalations, or fumes, talked much of by most philosophers; fumes being really no other than the humid parts of bodies respectively dry.

These vapours are demonstratively no other than small bubbles, or vesiculæ, detached from the waters by the power of the solar, or subterraneous heat, or both. Of which see Book ii. Chap. 5. Note (*b*). And being lighter than the atmosphere, are buoyed up thereby, until they become of an equal weight therewith, in some of its regions aloft in the air, or nearer the earth; in which those vapours are formed into clouds, rain, snow, hail, lightning, dew, mists, and other meteors.

In this formation of meteors the grand agent is cold, which commonly, if not always, occupies the superior regions of the air; as is manifest from those mountains which exalt their lofty tops into the upper and middle regions, and are always covered with snow and ice.

This

on the trees and plants, which would languish and die with perpetual drought, but are hereby made

\* This cold, if it approaches near the earth, presently precipitates the vapours, either in dews; or if the vapours more copiously ascend, and soon meet the cold, they are then condensed into misting, or else into showers of small rain, falling in numerous, thick, small drops: But if those vapours are not only copious, but also as heavy as our lower air itself (by means their bladders are thick and fuller of water) in this case they become visible, swim but a little height above the earth, and make what we call a mist or fog. But if they are a degree lighter, so as to mount higher, but not any great height, as also meet not with cold enough to condense them, nor wind to dissipate them, they then form an heavy, thick, dark sky, lasting oftentimes for several weeks without either sun or rain. And in this case, I have scarce ever known it to rain, 'till it hath been first fair, and then foul. And Mr. *Clarke* (an ingenious clergyman of *Norfolk*) who in his life-time, long before me, took notice of it, and kept a register of the weather for thirty years, which his learned grandson, Dr. *Samuel Clarke*, put into my hands, he (I say) saith, he scarce ever observed the rule to fail in all that time; only he adds, 'If the wind be in some of the easterly points.' But I have observed the same to happen, be the wind where it will. And from what hath been said, the case is easily accounted for; viz. whilst the vapours remain in the same state, the weather doth so too. And such weather is generally attended with moderate warmth, and with little or no wind to disturb the vapours, and an heavy atmosphere to support them, the barometer being com-



made verdant and flourishing, gay and ornamental;

monly high then. But when the cold approacheth, and by condensing drives the vapours into clouds or drops, then is way made for the sun-beams, till the same vapours, being by farther condensation formed into rain, fall down in drops.

The cold's approaching the vapours, and consequently the alteration of such dark weather, I have beforehand perceived, by some few small drops of rain, hail, or snow, now and then falling, before any alteration hath been in the weather; which I take to be from the cold meeting some of the straggling vapours, or the uppermost of them, and condensing them into drops, before it arrives unto, and exerts itself upon the main body of vapours below.

I have more largely than ordinary insisted upon this part of the weather, partly as being somewhat out of the way; but chiefly because it gives light to many other phenomena of the weather. Particularly we may hence discover the original of clouds, rain, hail, and snow; that they are vapours carried aloft by the gravity of the air, which meeting together so as to make a fog above, they thereby form a cloud. If the cold condenseth them into drops, they then fall in rain, if the cold be not intense enough to freeze them: But if the cold freezeth in the clouds, or in their fall through the air, they then become hail or snow.

As to lightning, and other enkindled vapours, I need say little in this place, and shall therefore only observe, that they owe also their rise to vapours; but such vapours as are detached from mineral juices, or at least they are mingled with them, and are fired by fermentation.

Another

mental; so that (as the Psalmist saith, *Psal. lxx.*  
12, 13.)

Another phænomenon resolvable from what hath been said is, why a cold, is always a wet summer; viz. because the vapours rising plentifully then, are by the cold soon collected into rain. A remarkable instance of this we had in the summer of 1708, part of which, especially about the solstice, was much colder than usually. On *June 12*, it was so cold, that my thermometer was near the point of hoar frost, and in some places I heard there was an hoar frost; and during all the cool weather of that month, we had frequent and large rains, so that the whole month's rain amounted to above two inches depth, which is a large quantity for *Upminster*, even in the wettest months. And not only with us at *Upminster*, but in other places, particularly at *Zurich* in *Switzerland*, they seem to have had as unseasonable cold and wet as we. 'Fuit hic mensis--præter modum humidus, & magno quidem vegetabilibus hominibusque damno. Multum computruit scænum, &c.' complains the industrious and learned *Dr. J. J. Scheuchzer*: Of which, and other particulars, I have given a larger account in *Phil. Transf. No. 321*.

In which Transaction I have observed further, that about the equinoxes we (at *Upminster* at least) have oftentimes more rain than at other seasons. The reason of which is manifest from what hath been said; viz. in spring, when the earth and waters are loosed from the brumal constipations, the vapours arise in great plenty: And the like they do in autumn, when the summer heats, that both disipated them, and warmed the superior regions, are cooled; and then the cold of the superior regions meeting them, condenseth them into showers, more plentifully

12, 13.) ' The little hills rejoice on every side,  
' and the vallies shout for joy, they also sing.'

And

plentifully than at other seasons, when either the vapours are fewer, or the cold that is to condense them is less.

The manner how vapours are precipitated by the cold, or reduced into drops, I conceive to be thus: Vapours being, as I said, no other than inflated vesiculæ of water; when they meet with a colder air than what is contained in them, the contained air is reduced into a less space, and the watery shell or case render'd thicker by that means, so as to become heavier than the air, by which they are buoyed up, and consequently must needs fall down. Also many of those thicken'd Vesiculæ run into one, and so form drops, greater or smaller, according to the quantity of vapours collected together.

As to the rain of different places, I have in some of our Transactions assigned the quantities; particularly in the last cited Transaction, I have assigned these; viz. the depth of the rain one year with another, in English measure, if it was to stagnate on the earth, would amount unto, at *Townly in Lancashire*, 42 inches and a half; at *Upminster in Essex*, 19 inches and a quarter; at *Zurich in Switzerland*, 32 inches and a quarter; at *Pisa in Italy*, 43 inches and a quarter; at *Paris in France*, 19 inches; and at *Lisse in Flanders* 24 inches.

It would be endless to reckon up the bloody, and other prodigious rains, taken notice of by historians, and other authors, as præternatural and ominous accidents; but if strictly pried into, will be found owing to natural causes: Of which, for the reader's satisfaction, I will give an instance or two. A bloody rain was imagined to have fallen in *France* which

And if to these uses, we should add the origin of fountains and rivers, to vapours and the

which put the country people into so great a fright, that they left their work in the fields, and in great haste flew to the neighbouring houses. *Peiresc* (then in the neighbourhood) strictly inquiring into the cause, found it to be only red drops coming from a sort of butterfly that flew about in great numbers at that time, as he concluded from seeing such red drops come from them; and because these drops were laid, 'Non super ædificia, non in devexis lapidum superficiebus, uti debuerat contingere, si è caelo sanguine pluisset; sed in subcavis potius & in foraminibus.-----Accessit, quod parietes iis tingebantur, non qui in mediis oppidis, sed qui agrorum vicini erant, neque secundum partes elatiores, sed ad mediocrem solum altitudinem, quantam volitare papiliones solent.' *Cassend. in vit. Peiresk.* 2. p. 156.

So Dr. *Merret* saith also, 'Pluvia sanguinis quam certissime constat esse tantum insectorum excrementa; pluvia tritici nihil aliud esse quam hederæ vacciferæ grana à sturnis devorata excretaque, comparanti liquidissimè patet. *Pinax rerum, &c.* p. 220.

The curious *Wormius* tells us of the raining of limstone, 'An. 1646. Maii 16. Hic hafnia cum ingenti pluviam tota urbs, omnesque ita inundarentur plateæ, ut gressus hominum impediret, sulphureoque odore aërem inficeret, dilapsis aliquantulum aquis, quibusdam in locis colligere licuit sulphureum pulverem, cujus portionem servo, colore, odore, & aliis verum sulphur ferentem.' *Mus. arm. l. 1. chap. 11. sect. 1.*

Together with the rain we might take notice of other meteors, particularly snow; which altho' an  
irksome

the rains, as some of the most eminent modern  
philosophers

irksome guest, yet hath its great uses, if all be true that the famous *T. Bartholin* saith of it, who wrote a book, *De nivis usu medico*. In which he shews what great use snow is in fructifying the earth, preserving from the plague, curing fevers, cholicks, head-aches, tooth-aches, sore eyes, pleurisies, (for which use, he saith, his country-women of *Denmark* keep snow-water gathered in *March*) also in prolonging life (of which he instanceth in the *Alpine* inhabitants, that live to a great age) and preserving dead bodies; instances of which he gives in persons buried under the snow in passing the Alps, which are found uncorrupted in the summer, when the snow is melted; which sad spectacle he himself was an eye-witness of. And at *Spitzberg* in *Greenland*, dead bodies remain entire and uncorrupted for thirty years. And lastly, concerning such as are so preserved when slain, he saith they remain in the same posture and figure: Of which he gives this odd example: ‘*Visum id extra urbem nostram [Hafnia] quum, 11 Feb. 1659. oppugnantes hostes repulerentur, magnâque strage occumberent; alii erant rigidi iratum vultum ostendebant, alii oculos clausos; alii ore diducto ringentes, alii brachiis extensis gladium minari, alii alio situ prostrati jacebant.*’ *Barthol. de usu niv. a. 12.*

But altho’ snow be attended with the effects here named, and others specified by the learned *Bartholin*; yet this is not to be attributed to any peculiar virtue in the snow, but some other cause. Thus when it is said to fructify the earth, it doth so by guarding the corn or other vegetables against the intenser cold of the air, especially the cold piercing winds; which the husbandmen observe to be the

most injurious to their corn of all weathers. So for conserving dead bodies, it doth it by constipating such bodies, and preventing all such fermentations or internal conflicts of their particles, as would produce corruption.

Such an example as the preceeding, is said to have happened some years ago at *Paris*, in digging in a cellar for supposed hidden treasure; in which, after digging some hours, the maid going to call her master, found them all in their digging postures, but dead. This being noised abroad, brought in not only the people, but magistrates also, who found them accordingly; 'Ille qui ligone terram effoderat, & socius qui palâ effossam terram removerat, ambo pedibus stabant, quasi suo quisque operi affixus incubuisset; uxor unius quasi ab opera defessa in scamno, sollicito quodam vultu, sedebat, inclinato in palmam manûs genibus innitentis capite; puerulus laxatis braccis in margine excavatæ foveæ defixis in terram oculis alvum exonerabat; omnes in naturali situ, carneæ tanquam statutz rigidi, apertis oculis & vultu vitam quasi respirante, exanimis stabant.' *Dr. Bern. Conner. Dissert. med. p. 15.*

The Doctor attributes all this to cold; but I scarce think there could be cold enough to do all this at *Paris*, and in a cellar too. But his following stories are not improbable, of men and cattle killed with cold, that remained in the very same posture which they died; of which he gives, from a Spanish Captain, this instance, that happened two years before, of a soldier who unfortunately straggled from his company that were foraging, and was killed with cold, but was thought to have fallen into the enemies hands. But soon after their return to their quarters, they saw their comrade returning, sitting on



philosophers (*b*) have done, we should have another instance of the great use and benefit of that meteor.

And now, if we reflect upon this necessary appendage of the terraqueous globe, the atmosphere, and consider the absolute necessity thereof to many uses of our globe, and in great convenience to the whole: And in a word, that it answereth all the ends and purposes that we can suppose there can be for such an appendage: who can but own this to be the contrivance, the work of the great Creator? Who would ever say or imagine such a body, so different from the globe it serves, could be made by chance, or be adapted exactly to all those forementioned grand ends by any other efficient than by the power and wisdom of the infinite God! Who would rather, from so noble a work, readily acknowledge

on horseback; and coming to congratulate him, found him dead, and that he had been brought thither in the same posture on horseback, notwithstanding the jolting of the horse. *Ibid.* p. 18.

(*b*) Of this opinion was my late most ingenious and learned friend, Mr. Ray, whose reasons see in his *Physico-theolog. Discourses, Disc. 2. ch. 2. p. 89*. So also my no less learned and ingenious friend Dr. Halley, and the late Dr. Hook; many of the French Virtuoso's also, and divers other very considerable men before them, too many to be specified here.

edge the workman, (c) and as easily conclude the atmosphere to be made by God, as an instrument wrought by its power, any pneumatick engine, to be contrived and made by man!



CHAP. IV.  
OF LIGHT.

**T**HUS much for the first thing ministring to the terraqueous globe, the atmosphere and its meteors; the next appendage is Light.(a) Concerning which, I have in my survey of the heaven,

(c) 'An Polycletum quidem admirabimur propter partium statuae----- convenientiam ac proportionem? Naturam autem non modo non laudabimus, sed omni etiam arte privabimus, quæ partium proportionem non solum extrinsecus more statuariorum, sed in profundo etiam servavit? Nonne & Polycletus ipse naturæ est imitator, in quibus saltem eam potuit imitari? Potuit autem in solis externis partibus, in quibus artem consideravit.' With much more to the like purpose. Galen. *de us. part. I, 17. c. I.*

(a) It is not worth while to enumerate the opinions of the Aristotelians, Cartesians, and others, about the nature of light: *Aristotle* making it a quality; *Cartes* a pulsion, or motion of the globules of the second element. *Vide Cartes princip. p. 3. sect. 55, &c.* But with the moderns, I take Light to consist of material particles, propagated from the sun, and other luminous bodies, not instantaneously,

heavens (b) shewed what admirable contrivances the infinitely wise Creator hath for the affording this noble, glorious, and comfortable benefit to other globes, as well as ours; the provision he hath made by moons, as well as by the sun, for the communication of it.

And now let us briefly consider the great necessity and use thereof to all our animal world. And this we shall find to be little less than the very life and pleasure of all those creatures. For what benefit would life be of, what pleasure, what comfort would it be for us to live in perpetual darkness? How could we provide ourselves with food and necessaries? How could we go about the least business, correspond with one another, or be of any use in the world, or any creatures be the same to us, without light, and those admirable organs of the body, which the great Creator hath adapted to the perception of that great benefit?

But in time, according to the notes following in this chapter. But not to insist upon other arguments for the proof of it, our noble founder hath proved the materiality of light and heat, from actual experiments on silver, copper, tin, lead, spelter, iron, tutenage, and other bodies, exposed (both naked and closely shut up) to the fire; all which were constantly found to receive an increment of weight. I wish he could have met with a favourable season to have tried his experiments with the sun-beams as he intended. *Vide Boyle's exper. to make fire and flame ponderable.*

(b) Astro-theol, book vii,

But now by the help of this admirable, this first-made (c), because most necessary, creature of God; by this, I say, all the animal world is enabled to go here and there, as their occasions call; they can transact their business by day, and refresh and recruit themselves by night, with rest and sleep. They can with admiration and pleasure, behold the glorious works of God; they can view the glories of the heavens, and see the beauties of the flowry fields, the gay attire of the feather'd tribe, the exquisite garniture of many quadrupeds, insects, and other creatures; they can take in the delightful landskips of divers countries and places; they can with admiration see the great Creator's wonderful art and contrivance in the parts of animals and vegetables: and, in a word, behold the harmony of this lower world, and of the globes above, and survey God's exquisite workmanship in every creature.

To all which I might add the improvements which the sagacity of men hath made of this noble creature of God, by the refractions and reflections of glasses. But it would be endless to enumerate all its particular uses and benefits to our world.

But before I leave this point, there are two things concerning light, which will deserve an especial remark; and that is, its swift and almost instantaneous motion, and its vast extension.

E 2

1. It

(c) 'And God said, let there be light, and there was light.' *Gen. i. 3.*

1. It is a very great act of the providence of God, that so great a benefit as light is, is not long in its passage from place to place. For was the motion thereof no swifter than the motion of the swiftest bodies on earth, such as of a bullet out of a great gun; or even of a sound (*d*) (which is the swiftest motion we have next to light) in this case light would take up, in its progress from the sun to us, above thirty-two years, at the rate of the first; and above seventeen years, at the rate of the latter motion. The

(*d*) It may not be ungrateful to the curious, to take notice of the velocity of these two things.

According to the observations of *Mersennus*, a bullet shot out of a great gun, flies 92 fathom in a second of time (*Vide* *Mersen. Balist.*) which is, equal to 589 English feet and a half; and, according to the computation of *Mr. Huygens*, it would be 25 years in passing from the earth to the sun. But according to my own observations made with one of her late Majesty's sakers, and a very accurate pendulum-chronometer, a bullet at its first discharge, flies 510 yards in five half seconds, which is a mile in a little above 17 half seconds. And allowing the sun's distance to be, as in the next note, a bullet would be 32 years and a half in flying, with its utmost velocity, to the sun.

As to the velocity of sounds, see *book iv. chap. 3. note 28.* according to which rate there mentioned, a sound would be near 17 years and a half in flying as far as the distance is from the earth to the sun. Confer here the experiments of the *Acad. del Ciment. p. 140, &c.*

The inconveniencies of which would be, its energy and vigor would be greatly cooled and abated ; its rays would be less penetrant ; and darkness would with greater difficulty and much sluggishness, be dissipated, especially by the fainter lights of our sublunary, luminous bodies. But passing with such prodigious velocity, with nearly the instantaneous swiftness of almost two hundred thousand English miles in one second of time, (e) or (which is the same thing) being but about seven or eight minutes of

(e) Mr. Romer's ingenious hypothesis about the velocity of light, hath been established by the Royal Academy, and in the Observatory, for eight years, as our *Phil. transf.* N<sup>o</sup> 136. observe from the *Journ. des Sçavans* ; our most eminent astronomers also in England admit it : But Dr. Hook thinks with Monsieur Cartes, the motion of light instantaneous, Hook's *Post. works*, page 77. And this he endeavours to explain, page 130, &c.

What Mr. Romer's hypothesis is, may be seen in the *Phil. transact.* before-cited : as also in the before-mentioned Sir Isaac Newton's *Opticks*, 'Light is propagated from luminous bodies in time, and spends about seven or eight minutes of an hour in passing from the sun to the earth. This was first observed by Romer, and then by others, by means of the eclipses of the satellites of Jupiter. For these eclipses, when the earth is between the Sun and Jupiter, happen about seven or eight minutes sooner than they ought to do by the tables ; and when the earth is beyond the sun, they happen about seven or eight minutes later than they ought



of an hour in coming from the sun to us, therefore with all security and speed, we receive the kindly effects and influences of that noble and useful creature of God.

2. Another thing of great consideration about light is, its vast expansion, its almost incomprehensible and inconceivable extension, which, as a late ingenious author (f) saith, "is as boundless and unlimited as the universe itself, or the expansum of all material Beings: The vastness of which is so great, that it exceeds the comprehensions of man's understanding. Insomuch, that very many have asserted it absolutely infinite, and without any limits or bounds."

And that this noble creature of God is of this extent, (g) is manifest from our seeing some

to do: The reason being, that the light of the satellites hath farther to go in the latter case than in the former, by the diameter of the earth's orbit. *Newt. opt. l. 2. part. 3. prop. 11.*

Now forasmuch as the distance between the sun and the earth (according to the computation in my *Astro-theology*, b. i. ch. 3. note 2.) is 86,051,398 English miles; therefore, at the rate of 7 minutes and a half, or 450 seconds, in passing from the sun, light will be found to fly above 191,225 miles in one second of time.

(f) Dr. Hook's posthumous works. *Lect. of light*, p. 76.

(g) For the proof of this vast extent of light, I shall take the computation of the same great man, page 77. "If (saith he) we consider first, the vast distance between us and the sun, which from the

the farthest distant objects, the heavenly bodies, some with our naked eye, some with the help

best and latest observations in astronomy, is judged to be about 10,000 diameters of the earth; each of which is about 7925 English miles; therefore the sun's distance is 7,925,000 miles; and if we consider, that, according to the observations, which I published to prove the motion of the earth [which were observations of the parallax of some of the fixed stars in the head of Draco, made in 1699] the whole diameter of the orb, viz. 20,000, made the subtense of but one minute to one of the fix'd stars, which cannot therefore be less distant than 3438 diameters of this great orb, and consequently 68,760,000 diameters of the earth: and if this star be one of the nearest, and that the stars that are of one degree lesser in magnitude, (I mean not of the second magnitude, because there may be many degrees between the first and second) be as much farther; and another sort yet smaller be three times as far; and a fourth four times as far, and so onward, possibly to some 100 degrees of magnitude, such as may be discovered by longer and longer telescopes, that they may be 100 times as far; then certainly this material expansion, a part of which we are, must be so great, that 'twill infinitely exceed our shallow conceptions to imagine. Now, by what I last mentioned, it is evident, that light extends itself to the utmost imaginable parts, and by the help of telescopes, we collect the rays, and make them sensible to the eye, which are emitted from some of the almost inconceivably remote objects, &c.----- Nor is it only the great body of the sun, or the vast bodies of the fixed stars, that are thus able to disperse the light thro' the vast expansum of the universe; but

help of optical instruments, and others in a probability farther and farther, with better and better instruments: And had we instruments of power equivalent to the extent of light, the luminous bodies of the utmost parts of the universe, would, for the same reason, be visible too.

Now as light is of greatest use to improve us to see objects at all, so the extension thereof is no less useful to enable us to see objects afar off. By which means we are afforded a knowledge of those many glorious works of the infinite Creator, visible in the heavens, and can improve them to some of the noblest sciences and most excellent uses of our own globe.

‘ but the smallest spark of a lucid body must do the  
 ‘ very same thing, even the smallest globule struck  
 ‘ from a steel by a flint, &c.

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## CH A P. V.

### OF GRAVITY.

**T**HE last thing subservient to our globe, that I shall take notice of, is gravity (or, that tendency which bodies have to the centre of the earth.

(a) That there is such a thing as Gravity, is manifest from its effects here upon earth; and that the heavenly bodies attract or gravitate to one another when placed at due distances, is made highly probable by Sir *Isaac Newton*. This attractive, or gravitating power, I take to be congenial to matter, and

In my *Astro-theology*, book vi. chap. 2. I have shewn of what absolute necessity, and what

imprinted on all the matter of the universe by the Creator's Fiat at the Creation. What the cause of is, the Newtonian Philosophy doth not pretend to determine for want of phenomena, upon which foundation it is that that philosophy is grounded, and not upon chimerical and uncertain hypotheses: But whatever the cause is, 'that cause penetrates even to the centres of the sun and planets, without any diminution of its virtue; and it acteth not according to the superficies of bodies (as mechanical causes do) but in proportion to the quantity of their solid matter: And lastly, it acteth all round at immense distances, decreasing in duplicate proportion to those distances, as Sir *Isaac Newton* hath, *Princip.* page ult. What useful deductions, and what a rational philosophy, have been drawn from hence, may be seen in the same book.

This attraction, or gravity, as its force is in a certain proportion, so makes the descent of bodies to be at a certain rate. And was it not for the resistance of the medium, all bodies would descend to the earth at the same rate; the lightest down, as swiftly as the heaviest mineral: as is manifest in the air-pump, in which the lightest feather, dust, &c. and a piece of lead, drop down seemingly in the same time, from the top to the bottom of a tall exhausted receiver.

The rate of the descent of heavy bodies, according to *Galileo*, Mr. *Huygens*, and Dr. *Halley* (after them) is 16 feet one inch in one second of time; and in more seconds, as the squares of those times. But some accurate experiments made in *St. Paul's* dome,

what a noble contrivance this of gravity is, for keep-

dome, *June 9, 1710*, at the height of 220 feet, the descent was scarcely 14 feet in the first second. The experiments were made in the presence of some very considerable members of the Royal Society, by Mr. *Hawksbee*, their operator, with glafs, hollow balls, some empty, some filled with quick-silver, the barometer at 297, the thermometer 60 degrees above freezing. The weight of the balls, their diameters, and time of the descent is in this table.

Balls filled with Quicksilver.		
Weight.	Diameter.	Time.
Grains.	Tenth Inch.	Half Seconds.
9908	8	8
993	8	8 less.
866	8	8
747	7 & half	8 more.
808	7 & half	8
784	7 & half	8 more.

Empty Ball.			
Weight.	Diameter.	Time.	
Grains.	Inch.	Tenth.	Half Seconds.
510	5	1	17
642	5	2	16
599	5	1	16
515	5 nearly.		16 & half
483	5 nearly.		17
641	5	2	16

keeping the several globes of the universe from  
 shattering to pieces, as they evidently must do  
 in a little time, by their swift rotation round  
 their own axis (b). The terraqueous globe  
 par-

The reason why the heavy full balls fell in half  
 the time of the hollow ones, was the resistance of the  
 air: which resistance is very ingeniously and accu-  
 rately assigned by Dr. *Wallis*, in *Philos. transf.* N<sup>o</sup> 186.  
 and the cause of the resistance of all fluids (as Sir  
*Isaac Newton*, Op. Q. 20) is partly from the friction  
 of the parts of the fluid, partly from the Inertia  
 thereof. The resistance a spherical body meets with  
 from friction, is as the right angle under the diame-  
 ter, and the velocity of the moving body: and the  
 resistance from the *Vis inertiz*, is as the square of  
 that product.

For a farther account of the properties and pro-  
 portions, &c. of gravity, in the fall or projection  
 of bodies, I shall refer to the larger accounts of  
*Galileus*, *Torricellius*, *Huygens*, Sir *Isaac Newton*, &c.  
 to the shorter accounts of Dr. *Halley*, in *Philos.*  
*transact.* abridged by Mr. *Lowthorp*, vol. 1.  
 561. or Dr. *Clarke*, in his notes on *Robault*,  
 2. c. 28. § 13. 16. And for the resistance  
 of fluids, I refer to Dr. *Wallis*, before-cited, and  
 to *AE. Erudit. Lips.* May 1693, where there is  
 a way to find the force of mediums upon bodies of  
 different figures.

(b) That the heavenly bodies move round their  
 own axis, is, beyond all doubt, manifest to our eye,  
 some of them, from the spots visible on them.  
 The spots on the sun (easily visible with an ordinary  
 telescope) do manifest him to revolve round his own  
 axis in about 25 days and a quarter. The spots



particularly, which circumvolves at the rate of above 1000 miles an hour (c), would by the centrifugal force of that motion, be soon dissipated and spirtled into the circumambient space, was it not kept together by this noble contrivance of the Creator, this natural inhe-

on Jupiter and Mars prove those two planets to revolve also from east to west, as Dr. Hook discovered in 1664, and 1665. And Venus also (altho' near the strong rays of the sun) hath, from some spots been discovered by Mr. Cassini, in 1666, and 1667, to have a manifest rotation. Vide *Louthorp's* abridg. vol. I. p. 382, and 423, 425. And such uniformity hath the Creator observed in the works of nature, that what is observable in one, is generally to be found in all others of the same kind. So that since 'tis manifest the sun, and three of his planets whirl round, it is very reasonable to conclude the rest do so too; yea, every globe of the universe.

(c) The earth's circumference being 25,031 miles and half (according to book ii. chap. 2. note c) if we divide that into 24 hours, we shall find the motion of the earth to be near 1043 miles in an hour. Which, by the by, is a far more reasonable and less rapid rate, than that of the sun would be if we suppose the earth to stand still, and the sun move round the earth. For according to the proportions in note (c), of the preceding chapter, the circumference of the *magnus orbis* is 340,688 English miles, which divided by 24 hours, gives 22,528,364 miles in an hour. But what is this to the rapidity of the fix'd stars, if we suppose them not the earth, to move? Which is a good argument for the earth's motion.

ent power, namely, the power of attraction or gravity.

And as by this power our globe is defended against dissipation, so all its parts are kept in their proper place and order. All material things do naturally gravitate thereto, and unite themselves therewith, and so preserve its bulk entire (*d*). And the fleeting waters, the most unruly of all its parts, do by this means keep their constant æquipoise in the globe (*e*). and remain in that place which the Psalmist saith, 'God hath founded for them; a bound he had set, which they might not pass; that they turn not again to cover the earth, *Psal.* iv. 8, 9.' So, that even in a natural way, by virtue of this excellent contrivance of the Creator, the observation of the Psalmist is perpetually fulfilled, *Psal.* lxxxix. 9. 'Thou rulest

(*d*) 'Nihil majus, quàm quòd ita stabilis est mundus, atque ita cohæret ad permanendum, ut nihil ne excogitari quidem possit aptius. Omnes enim partes ejus undique medium locum capessentes, nituntur æqualiter: maximè autem corpora inter se juncta permanent, cùm quodam quasi vinculo circumdata colligantur: quod facit ea natura, quæ per omnem mundum omnia mente, & ratione conficiens, funditur, & ad medium rapit, & convertit extrema.' *Cic. de nat. cor.* l. 2. c. 45.

(*e*) 'Eâdem ratione mare, cùm supra terram sit, medium tamen terræ locum expetens, conglobatur undique æqualiter, neque redundat unquam, neque effunditur.' *Idem paulo post.*

‘rulest the raging of the sea ; when the waves  
‘thereof arise, thou stillest them.’

To these, and an hundred other uses of gravity that I might have named, I shall only just mention another thing owing to it, and that is levity (*f*), that, whereby what we call light bodies swim, a thing no less useful to the world than its opposite, gravity, is in many respects, to divers tribes of animals, but particularly serviceable to the raising up of vapours (*g*), and to their conveyance about the world.

And

(*f*) That there is no such thing as positive levity, but that levity is only a less gravity, is abundantly manifested by the acute Seign. *Alph. Borelli de nat. à grav. pend. cap. 4.* See also the annotations of the learned and ingenious Dr. *Clarke* on *Robinson's phys.* p. 1. c. 16. note 3. Also the experiments of the *Acad. del Cimento*, p. 118, &c. Dr. *Wallis's* discourse of gravity and gravitation before the Royal Society, *Nov. 12. 1674.* p. 28, &c.

(*g*) I have before, in note (*a*), chap. 3. shewn what vapours are, and how they are raised. That which I shall here note, is their quantity: Concerning which, the before-commended Dr. *Hall* hath given us some curious experiments in our *Philosoph. transact.* which may be met with together in Mr. *Lewthorp's* Abridg. vol. II. p. 108, and 126. Mr. *Sedileau* also, at Paris, observed it for near three years. By all their observations it appears, that in the winter months the evaporations are least, and greatest in summer, and most of all in windy weather. And by Mons. *Sedileau's* observations it appears

And now from this transient view of no other than the out-works, than the bare appendages of the terraqueous globe, we have to manifest a sample of the wisdom, power, and goodness of the infinite Creator, that it is easy to imagine the whole fabrick is of a piece, the work of, at least, a skilful artist. A man that should meet with a palace (*b*) beset with pleasant gardens, adorned with stately avenues, furnished with well-contrived aqueduct,

sees, that what is raised in vapours, exceeds that which falleth in rain. In the seven last months of the year 1688, the evaporations amounted to 22 inches 5 lines; but the rain only 10 inches 6 lines one third: In 1689, the evaporations were 32 inches 10 lines and a half; but the rain 18 inches one line: In 1690, the evaporations 32 inches 11 lines; the rain 21 inches one third of a line. *Vide Mem. de math. phys. an. 1692. p. 25.*

If it be demanded, what becomes of the overplus of exhalations that descend not in rain? I answer, they are partly tumbled down and spent by the winds, and partly descend in dews, which amount to a greater quantity than is commonly imagined. Dr. Halley found the descent of vapours in New so prodigious at St. Helena, that he makes no doubt to attribute the origin of fountains thereto. And I myself have seen in a still, cool evening, large thick clouds hanging, without any motion, in the air, which in two or three hours time have been melted down by degrees, by the cold of the evening, so that not any the least remains of them have been left.

(*b*) See Book ii. chap. 3. note (*c*).

ducts, cascades, and all other appendages conducing to convenience or pleasure, would easily imagine, that proportionable architecture and magnificence were within : But we should conclude the man was out of his wits that should assert and plead, that all was the work of chance, or other than of some wise and skilful hand. And so when we survey the bare outworks of this our globe, when we see so vast a body, accouter'd with so noble a furniture of air, light, and gravity ; with every thing, in short, that is necessary to the preservation and security of the globe itself, or that conduceth to the life, health, and happiness, to the propagation and increase of all the prodigious variety of creatures the globe is stocked with ; when we see nothing wanting, nothing redundant or frivolous, nothing botching or ill-made, but that every thing, even in the very appendages alone, exactly answereth all its ends and occasions : what else can be concluded, but that all was made with manifest design, and that all the whole structure is the work of some intelligent Being, some artist, of power and skill equivalent to such a work ?

## B O O K II.

### *Of the Terraqueous Globe itself in general.*

**I**N the foregoing book having dispatched the outworks, let us take a survey of the principal fabrick; viz. the Terraqueous Globe itself; a most stupendous work in every particular of it, which doth no less aggrandize its Maker (a), than every curious, complete work doth its workman. Let us cast our eyes

(a) ' Licet-----oculis quodammodo contemplari pulchritudinem earum rerum, quas divinâ providentiâ dicimus constitutas. At principio terra universa cernatur, locata in mediâ mundi sedē, solida, & globosa-----vestita floribus, herbis, arboribus, frugibus. Quorum omnium incredibilis multitudo, insatiabili varietate distinguitur. Adde huc fontium gelidas perennitates, liquores perlucidos amnium, riparum vestitus viridissimos, speculicarum concavas altitudines, saxorum asperitates, impendentium montium altitudines, imensitatesque camporum: Adde etiam reconditas Auri---venas---quæ verò, & quàm varia genera bestiarum? ----qui volucrum lapsus, atque cantus? qui pecudum pastus? --- quid de hominum genere dicam? qui quasi cultores terræ constituti, &c.--- quæ si, ut animis, sic oculis videre possemus, nemo cunctam intuens terram, de divinâ ratione dubitaret.' Cic, de nat. deor. l. 2.



eyes here and there, let us ransack all the globe, let us with the greatest accuracy inspect every part thereof, search out the inmost secrets of any of the creatures, let us examine them with all our gauges, measure them with our nicest rules, pry into them with our microscopes, and most exquisite instruments (b), still we find them to bear testimony to their infinite workman; and that they exceed all human skill so far, as that the most exquisite copies and imitations of the best artists, are no other than rude bungling pieces to them. And so far are we from being able to espy any defect or fault in them, that the better we know them, the more we admire them; and the further we see into them, the more exquisite we find them to be.

(b) 'I cannot here omit the observations that have been made in these latter times, since we have had the use and improvement of the microscope, concerning the great difference, which by the help of that, doth appear betwixt natural and artificial things. Whatever is natural, doth by that appear adorned with all imaginable elegance and beauty.-----Whereas the most curious works of art, the sharpest, finest needle, doth appear as a blunt, rough bar of iron, coming from the furnace, or the forge. The most accurate engravings or embossments seem such rude, bungling, deformed works, as if they had been done with a mattock, or a trowel. So vast a difference is there betwixt the skill of nature, and the rudeness and imperfection of art.' *Bishop Wilk. ser. rel. l. 1. c. 6.*

And for a demonstration of this, I shall,

I. Take a general prospect of the terra-queous globe.

II. Survey its particulars.

I. The things which will fall under a general prospect of the globe, will be its figure, bulk, motion, place, distribution into earth and waters, and the great variety of all things upon it, and in it.

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C H A P. I.

*Of the Figure of the Terraqueous Globe.*

**T**HIS I suppose I may take for granted to be spherical, or nearly so (*a*). And this must be allowed to be the most commodious, apt figure for a world, on many accounts; as it is most capacious, as its surface

is

(*a*) Altho' the terraqueous globe be of an orbicular figure, yet it is not strictly so, 1. On account of its hills and vallies. But these are inconsiderable to the earth's semi-diameter; for they are but as the dust upon a common globe. But, 2. Our modern astronomers assign a much greater variation from a globous form, namely, that of a prolate spheroid, making the polar about 34 miles shorter than the equatorial diameter. The cause of which, they make to be the centrifugal force of the diurnal rotation of the globe.

This figure they imagine is in Jupiter, his polar being to his equatorial diameter, as 39 three fifths

is equi-distant from the centre, not only of the globe, but at least (nearly) of gravity and motion too, and as some have thought, of the central heat and waters. But these, and divers other things I shall pass over, and insist only upon two or three other benefits of the globous figure of the earth and waters.

1. This figure is the most commodious in regard of heat, and I may add of light also

to 40 three fifths. But whether it be so or no, I confess I could never perceive, altho' I have often viewed that planet through very good, and long glasses, particularly a tolerable good one of 72 feet in my hands: And although by reason of cloudy weather, and (at present) Jupiter's proximity to the sun, I have not been of late able to take review of that planet; yet Saturn (so far as the ring would permit) and Mars appear perfectly round, through Mr. *Huygens's* long glass of 12 feet, which by will he bequeathed, with its whole apparatus, to our Royal Society, by whose favour it is now in my hands. And moreover, I believe it difficult, next to impossible, to measure the true diameters to a 40th part, by reason of the smallness of Jupiter's apparent diameter, and by reason he is moving all the time of measuring him.

As to what is alledged from lengthening the pendulums of clocks to make them keep the same time under the equator, as they do in our climate, I have shewn from the like variations in the air pump, that this may arise from the rarity of the air there, more than here. *Vide Phil. trans. N<sup>o</sup> 49*. But if the degrees of a meridian grow larger, the more we go towards the line (as Mr. *Cassini* affirm

some measure: For by this means, those two great benefits are uniformly and equally imparted to the world: they come harmoniously and gradually on, and as gradually go off again. So that the daily and yearly returns of light and darkness, cold and heat, moist and dry, are regular and workman-like (we may say) which they would not be, especially the former, if the mass of earth and waters were

they do, by an 800th part in every degree, in Phil. Trans. N<sup>o</sup> 278.) then there is great reason to conclude in behalf of this spheroidal form.

The natural cause of this sphericity of our globe, (according to Sir *Isaac Newton's* principles) that attraction which the infinite Creator hath stamp'd on all the matter of the universe, whereby all bodies, and all the parts of bodies, mutually attract themselves, and one another. By which means, as all the parts of bodies tend naturally to their center, so they all betake themselves to a globous figure, unless some other more prevalent cause interpose. Thus drops of quicksilver put on a spherical form, the parts thereof strongly attracting one another. So drops of water have the same form, when falling in the air; but the hemispherical only when they lie on a hard body, by reason their gravity is so far over-power their self-attracting power, as to take off one half of their sphericity. This figure is commonly attributed to the pressure of the circumambient air: but that this can't be the cause, is manifest from the air-pump; the case being the very same in an exhausted receiver, as in the open air, and not any the least alteration of the figure that I could perceive, in all the trials I have made.

were (as some fancied (*b*) it) a large plain ; or as others, like a large hill in the midst of the ocean ; or of a multangular figure ; or such like.

2. This figure is admirably adapted to the commodious and equal distribution of the waters in the globe. For since, by the laws of gravity, the waters will possess the lowest place ; therefore, if the mass of the earth was cubick, prismatick, or any other angular figure, it would follow, that one (too vast a part) would be drowned, and another be too dry. But being thus orbicular, the waters are equally and commodiously distributed here and there, accor-

(*b*) It would be frivolous, as well as endless, to reckon up the various opinions of the ancients about the figure of the terraqueous globe ; some of them may be seen in *Varen. Geogr. l. 1. c. 3. init.* or *Johnston's Thaum. c. 3. artic. 3.* But among the variety of opinions, one of the principal was, that the visible horizon was the bounds of the earth, and the ocean the bounds of the horizon ; that the heavens and earth above this ocean, was the whole visible universe ; and that all beneath the ocean was Hades, or the invisible world. Hence, when the Sun set, he was said, *Tingere se oceano* ; and when any went to Hades, they must first pass the ocean. Of this opinion were not only the ancient poets, and other among the heathens, but some of the christian fathers too, particularly *Lactantius*, *St. Augustine*, and others, who thought their opinion was favour'd by the Psalmist, in *Psal. xxiv. 2.* and *cxxxvi. 6.* See Bishop *Usher's* answer to a *Jes. chall. p. 366, &c.*

According as the divine providence saw most fit; of which I shall take notice by and by.

3. The orbicular figure of our globe is far the most beneficial to the winds and motions of the atmosphere: It is not to be doubted, if the earth was of some other, or indeed any other figure, but that the currents of air would be much retarded, if not wholly stopped. We find by experience, what influence large and high mountains, bays, capes, and head-lands have upon the winds; how they stop some, retard many, and divert and change (near the shores) even the general and constant winds (c), that blow round the globe in the torrid zone. And therefore, since this is the effect of such little

(c) 'Neither do these constant Trade-winds usually blow near the shore, but only on the ocean, at least thirty or forty leagues off at sea, clear from any land; especially on the west coast, or side of any continent: for indeed on the east side, the easterly wind being the true trade-wind, blows almost home to the shore, so near as to receive a check from the land-wind.' *Dampier's* *Travels*, chap. I.

And not only the general trade-winds, but also the constant coasting trade-winds, are in like manner affected by the lands. Thus, for instance, on the coast of *Angola* and *Peru*. But this, saith the famous captain *Dampier*, the reader must take notice of, 'That the trade-winds that blow on any coast, except the north coast of *Africa*, whether they are constant, and blow all the year, or whether they are shifting winds, do never blow right in



little excrescences, which have but little proportion to our globe, what would be the consequences of much vaster angles, which would equal a quarter, tenth, or but an hundredth part of the globe's radius? Certainly there must be such a barricade, as would greatly annoy, or rather absolutely stop, the currents of the atmosphere, and thereby deprive the world of those salutiferous gales that I have said keep it sweet and clean.

Thus the figure of our globe doth manifest it to be a work of contrivance, inasmuch as it is of the most commodious figure; and all others would be liable to great and evident inconveniencies.

‘ in on the shore, nor right along shore, but  
‘ slanting, making an acute angle of about 22 de-  
‘ grees. Therefore, as the land tends more  
‘ or west, from north or south on the coast, so the  
‘ winds do alter accordingly. ’ *Ibid.*, chap. 2.

C H A P II.

*Of the bulk of the Terraqueous Globe.*

**T**HE next thing remarkable in the terra-queous globe, is the prodigious bulk thereof (a). A mass of above 260 thousand million of miles solid content. A work too grand for any thing less than a God to make. To which, in the next place, we may add,

(a) It is not difficult to make a pretty near computation of the bulk of the terraqueous globe, from those accurate observations of a degree made by Mr. Norwood in England, and Mr. Picart, and Mr. Cassini in France, whose measures do in a surprising manner agree. But Mr. Cassini's seeming to be the most accurate (as I have shewn in my Astro-theology, book i. ch. 2. note (a).) I have therefore made use of his determinations. According to which, the diameter of the earth being 7926 English miles, its ambit will be 25,031 miles and half; and (supposing it to be spherical) its surface will be 199,444,220 miles; which being multiplied into one third of its semidiameter, gives the solid content; viz. 264856,000,000 miles.



## C H A P. III.

*The Motions of the Terraqueous Globe.*

THE motions the terraqueous globe hath are round its own axis, and round in fountain of light and heat, the sun (*a*). That so vast a body as the earth and waters should be moved at all (*b*), that it should undergo two such different motions as the diurnal and annual

(*a*) With the Copernicans, I take it here for granted, that the diurnal and annual revolutions are the motions of the terraqueous globe, not of the sun, &c. but for the proof thereof I shall refer the reader to the preface of my Astro-theology, and book iv. chap. 3.

(*b*) ' Every thing that is moved, must of necessity be moved by something else; and that thing is moved by something that is moved either by another thing, or not by another thing. If it be moved by that which is moved by another, we must of necessity come to some prime mover, that is not moved by another. For it is impossible, that what moveth, and is moved by another, should proceed in infinitum.' *Aristot. Phys.* l. 8. c. 5.

' Solum quod seipsum movet, quod nunquam deseritur à se, nunquam ne moveri quidem desinit: quinetiam cæteris quæ moventur, hic fons, hoc principium est movendi. Principii autem nulla est origo: nam ex principio oriuntur omnia; ipsum autem nullâ ex re alia nasci potest

ual are, and that these motions should be so constantly and regularly (c) performed for near 6000 years, without any the least alteration ever heard of (except some hours which we read of in *Josb. x. 12, 13.* and in *Hezekiab's* time, which, if they cannot be accounted for some

nec enim esset id principium, quod gigneretur aliunde.' *Cicer. Tusc. quæst. l. 1. c. 23.*

'Cogitemus quâ fieri possit, ut tanta magnitudo, ab aliquâ possit naturâ, tanto tempore circumferri? Ego igitur assero deum causam esse, nec aliter posse fieri.' *Plato in Epinom.*

(c) Among the causes which *Cleanthes* is said usually to assign for men's belief of a deity, one of the chief is, 'Æquabilitatem motûs, conversionem cœli, solis, lunæ, siderumque omnium distinctionem, varietatem, pulchritudinem, ordinem: quarum rerum aspectus ipse satis indicaret, non esse ea fortuita. Ut si quis in domum aliquam, aut in gymnasium, aut in forum venerit; cum videat omnium rerum rationem, modum, disciplinam, non possit ea sine causâ fieri judicare, sed esse aliquem intelligat, qui præsit, & cui pareatur: multo magis in tantis motibus, tantisque vicissitudinibus, tam multarum rerum atque tantarum ordinibus, in quibus nihil unquam immensa & infinita vetustas mentita sit, statuatur necesse est ab aliquâ mente tantos naturæ motus gubernari.' *de nat. deor. l. 2. c. 5.*

'Homines cœperunt deum agnoscere, cum viderent stellas, tantam concinnitatem efficere: ac dies, noctesque, æstate, & hyeme, suos servare statos ortus, atque obitus.' *Plutarch. de placit. l. 1. c. 6.*

some other way, do greatly increase the wonder (*d*); these things, (I say) do manifestly argue some divine infinite power to be concerned therein (*e*): But, especially, if to all this we add

(*d*) We need not be solicitous to elude the history of these miracles, as if they were only poetical strains, as *Maimonides*, and some others fancy *Yosbua's* day to have been; viz. only an ordinary summer's day; but such as had the work of many days done in it: and therefore by a poetical stretch made, as if the day had been lengthened by the sun standing still. But in the history they are seriously related, as real matters of fact, and with such circumstances as manifest them to have been miraculous works of the Almighty: And the prophet *Habakkuk*, *ch.* iii. 11. mentions that of *Yosbua* as such. And therefore taking them to be miraculous perturbations of the course of nature, instead of being objections, they are great arguments of the power of God: For in *Hezekiah's* case, to wheel the earth itself backward, or by some extraordinary refractions, to bring the sun's shadow backward 10 degrees: or, in *Yosbua's* case, to stop the diurnal course of the globe for some hours, and then again give it the same motion; to do, I say, these things required the same infinite power which at first gave the terraqueous globe its motion.

(*e*) *Nam cùm dispositi quæsissem fœdera mundi,  
Præscriptosque maris fines, annique meatus,  
Et lucis, noctisque vices; tunc omnia rebar  
Consilio firmata dei, qui lege moveri  
Sidera, qui fruges diverso tempore nasci,  
Qui variam Phœben alieno jussisset igne  
Compleri, solemque suo; porrexerit undis  
Littora; tellurem medio libraverat axe.*

*Claudian in Ruffin. l. 1. initio.*

the wonderful convenience, yea, absolute necessity of these circumvolutions to the inhabitants, yea, all the products of the earth and waters. For to one of these we owe the comfortable changes of day and night; the one for business, the other for repose (*f*); the one for man, and most other animals to gather and provide food, habitation, and other necessities of life; the other to rest, refresh, and recruit their spirits (*g*), wasted with the labours of the day. To the other of those motions we owe the seasons of summer and winter, spring and autumn, together with the beneficial influences and effects which these have on the bodies and state of animals, vegetables, and all other things, both in the torrid, temperate, and frigid zones.

(*f*) 'Diei noctisque vicissitudo conservat animantes, tribuens aliud agendi tempus, aliud quiescendi. Sic undique omni ratione concluditur, mune, consilioque divino omnia in hoc mundo ad salutem omnium, conservationemque admirabiliter administrari.' *Cicer. de nat. deor. l. 2. c. 53.*

(*g*) The acute Dr. *Cbeyne*, in his ingenious *Philos. princ. of natural religion*, among other uses of day and night, saith, the night is most proper for sleep; because when the sun is above the horizon, sleep is prejudicial, by reason the perspirations are then too great. Also, that nutrition is mostly, if not altogether, performed in time of rest; the blood having too quick a motion in the day; for which reason, weak persons, children, &c. are nourished most, and recruit best by sleep.



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## C H A P. IV.

*Of the place and situation of the terraqueous  
Globe, in respect of the Heavenly Bodies.*

**A**Nother thing very considerable in our globe, is its place and situation at a great distance from the sun (a), its fountain of light and heat; and from its neighbouring planets of the solar system, and from the fix'd stars. But these things I have spoken more largely of in my Survey of the Heavens (b), and therefore only barely mention them now, and insist more largely upon,

(a) It is a manifest sign of the Creator's management and care, in placing the terraqueous globe at that very distance it is from the sun, and contemplating our own bodies, and all other things, at a proper distance. For was the earth farther from the sun, the world would be starved and frozen with cold: and was it nigher, we should be burnt; at least the most combustible things would be so, and the world would be vexed with perpetual conflagrations. For we see that a few of the rays of the sun, even no more than what fall within the compass of half an inch, or an inch, in a burning-glass, will fire combustible bodies, even in our own climate.

(b) *Astro-theology*, book vii. chap. 7.

## C H A P. V.

*The distribution of the Earth and Waters.*

THE distribution of the waters, and the dry land, although it may seem rude and undesign'd to a careless view, and is by some tax'd as such (*a*), yet is admirably well adjusted to the uses and conveniencies of our world.

For

(*a*) The most eminent author I have met with, that finds fault with the distribution of the earth and waters, and indeed with the whole present structure of the globe, is the learned and eloquent theorist, Dr. Burnet; who frequently exclaims on this point: 'Tellus nostra, si totam simul complectamur, non est ordinata & venusta rerum compages---sed moles aggesta vario, incertoque situ partium, nullâ ordinis aut venustatis habitâ ratione. *Theor. Sacr. l. 1. c. 7.* Equis autem à deo hæc ita facta? &c. *ibid.* Quo autem herculeo labore opus esset ad excavandam terram in tantum hiatum?-----Si immediatè à causâ primâ effectus fuisset hic alveus, aliquem saltem ordinem, mensuram, & proportionem notare voluisset in ipsius formâ, & partium dispositione;---sed confusa omnia, &c. *ibid. c. 8.* Tellus nostra cum exigua sit, est etiam rudis: Et in illâ exiguitate multa sunt superflua, multa inelegantia. Dimidiam terræ superficiem inundat oceanus; magnâ ex parte, ut mihi videtur, inutilis.' And then he goes on to shew how this part of the creation might

For in the first place, the distribution is so well made, the earth and waters so handsomely, so workman-like laid, every where all the world over, that there is a just æquipoise of the whole globe. The Northern balanceth the Southern Ocean, the Atlantick the Pacifick Sea. The American dry land is a counterpoise to the European, Asiatick and African.

In the next place, the earth and the waters are so admirably well placed about in the globe, as to be helpful to one another, to minister to one another's uses. The great oceans, and the lesser seas and lakes, are so admirably well distributed throughout the globe (b), as

might be mended, *ibid.* c. 10. All this is to me surprizing, from an author of great ingenuity, who seems in his book to have a just opinion of, and due veneration for God. But certainly such notions are very inconsistent with the belief of God's creating, especially his governing and ordering the world. But suppose the teraqueous globe was such a rude, confused, inconvenient mass, as he pretends, yet it is well enough for a sinful world. But besides what others have long ago abundantly answered, the following survey will, I hope, sufficiently manifest it to be the work of a wise and beneficent, as well as omnipotent Creator.

(b) Some have objected against the distribution of the earth and waters, as if the waters occupied too large a part of the globe, which they think would be of greater use, if it was dry land. But then they do not consider that this would deprive the world of a due quantity of vapours and rain.

For

to afford sufficient vapours (c) for clouds and rain,

For if the cavities which contain the sea, and other waters, were deeper, although the waters were no less in quantity, only their surfaces narrower and lesser, the evaporations would be so much the less, inasmuch as those evaporations are made from the surface, and are, consequently, in proportion to the surface, not the depth or quantity of water.

(c) I took notice before, in book i. chap. 3. note (a), that the vapours constituting clouds and rain, are vesiculæ of water detached by heat. The manner of which I conceive to be thus; heat being of an agile nature, or the lightest of all bodies, easily breaks loose from them; and if they are humid, in its passage carries along with it particles, or little masses of the water; which being lighter than air, are buoyed up thereby, and swim in it; until by knocking against one another, or being thickened by the cold (as in the note before-cited) they are reduced into clouds and drops.

Having mentioned the manner how vapours are raised, and there being more room here than in the note before-cited, I shall, for the illustration of nature's process, take notice of three things observable to our purpose, in water over the fire. 1. That the evaporations are proportional to the heat ascending out of the water. A small heat throws off but few vapours, scarce visible: A greater heat, and ascending in greater quantities, carries off grosser, larger, and more numerous vesiculæ, which we call Steam: and if the heat breaks through the water with such a fury, as to lacerate and lift up great quantities or bubbles of water, too heavy for the air to carry or buoy up, it causeth what we call Boiling.

rains, to temperate the cold (d) of the northern  
frozen

**Boiling.** And the particles of water thus mounted up by the heat, are visible sphærules of water, if viewed with a microscope, as they swim about in a ray of the sun let into a dark room, with warm water underneath; where some of the vapours appear large, some smaller sphærules, according (no doubt) to the larger and lesser quantities of heat blowing them up and carrying them off. 2. If these vapours be intercepted in their ascent by any context, especially cold body; as glass, marble, &c. they are thereby reduced into drops, and masses of water, like those of rain, &c. 3. These vapours in their ascent from the water, may be observed, in cold frosty weather, either to rise but a little above the water, and there to hang, or to glide on a little above its surface: or if the weather be very cold, after a little ascent, they may be seen to fall back again into the water; in their ascent and descent describing a curve somewhat like that of an arrow from a bow. But in a warmer air, and still, the vapours ascend more nimbly and copiously, mounting up aloft, till they are out of sight. But if the air be warm and windy too, the vapours are sooner carried out of sight, and make way for others. And accordingly I have often observed, that hot liquors, if not set too thin, and not frequently stirred, cool slower in the greatest frosts, than in temperate weather, especially if windy. And it is manifest by good experiments, that the evaporations are less at those times than these; less by far in the winter than the warmer months.

(d) As our northern islands are observed to be more temperate than our continents (of which we had a notable instance in the great frost in 1708-9, which

frozen air, to cool and mitigate the heats (c) of

which Ireland and Scotland felt less of than most parts of Europe besides ; of which see book iv. chap. 12. note (c) so this temperature is owing to the warm vapours afforded chiefly by the sea, which, by the preceding note, must necessarily be warm, as they are vapours, or water inflated by heat.

The cause of this heat I take to be partly that of the sun, and partly subterraneous. That it is not wholly that of the sun, is manifest from vapours being as much, or more copiously raised when the sun-beams are weakest, as when strongest, there being greater rains and winds at the one time than the other. And that there is such a thing as subterraneous heat (whether central, or from the meeting of mineral juices ; or such as is congenial or consubstantial to our globe, I have not time to enquire ; but I say, that such a thing is) is evident not only from the hot-baths, many fiery eruptions and explosions, &c. but also from the ordinary warmth of cellars and places under ground, which are not bare, but comparatively warm, but of sufficient heat to raise vapours also : as is manifest from the smothering of perennial fountains in frosty weather, and water drawn out of pumps and open wells at such time. Yea, even animals themselves are sensible of it, as particularly moles, who dig before a thaw, and against some other alterations of the weather ; excited, no doubt, thereunto by the same warm vapours arising in the earth, which animate them, as well as produce the succeeding changes of the weather.

(c) Beside the trade-winds, which serve to mitigate the excessive heats in the torrid zone, the clouds are a good screen against the scorching sun-beams,



of the torrid zone, and to refresh the earth with fertile showers; yea, in some measure to minister fresh waters to the fountains and rivers. Nay, so abundant is this great blessing, which the most indulgent Creator hath offered us by means of this distribution of the waters I am speaking of, that there is more than a scanty, bare provision, or mere sufficiency; even a plenty, a surplussage of this useful creature of God (the fresh waters) afforded to the world, and they so well ordered, as not to drown the nations of the earth, nor to stagnate, stink, and poison, or annoy them; but to be gently carried through convenient channels back again to their grand fountain (f) the sea; and

many

beams, especially when the sun passeth their zenith; at which time is their winter, or coolest season, by reason they have then most clouds and rain. For which service, that which *Varen* takes notice of, is a great providence of God; viz. ‘*Pleraque loca zonæ torridæ vicinum habent mare, ut India, insulæ Indicæ, lingua Africæ, Guinea, Brasilia, Peruvia, Mexicana, Hispania: Pauca loca zonæ torridæ sunt Mediterranea.*’ *Varenii Geog.* l. 1. prop. 10. § 7.

(f) That springs have their origin from the earth and not from rains and vapours, among many other strong reasons, I conclude from the perennity of divers springs, which always afford the same quantity of water. Of this sort there are many to be found every where. But I shall, for an instance, single out one in the parish of *Upminster*, where I live, as being very proper for my purpose, and

many of them thro' such large tracts of land,  
and

that I have had better opportunities of making remarks upon above twenty years. This in the greatest droughts is little, if at all, diminished, that I could perceive by my eye, although the ponds all over the country, and an adjoining brook, have been dry for many months together; as particularly in the dry summer months of the year 1705. And in the wettest seasons, such as the summer and other months were, preceding the violent storm in November 1703. (*Vide Philos. Transf. N<sup>o</sup> 289.*) I say, in such wet seasons I have not observed any increment of its stream, excepting only from violent rains falling therein, or running down from the higher land into it; which discoloureth the waters oftentimes, and makes an increase of only a day's, or sometimes but a few hours continuance. But now, if this spring had its origin from rain and vapours, there would be an increase and decrease of the one, as there should happen to be of the other: as actually it is in such temporary springs as have undoubtedly their source from rain and vapours.

But besides this, another considerable thing in this *Upminster* spring (and thousands of others) is, that it breaks out of so inconsiderable an hillock, or eminence of ground, that can have no more influence in the condensation of the vapours, or stopping the clouds (which the maintainers of this hypothesis suppose) than the lower lands about it have. By some critical observations I made with a very nice portable barometer, I found that my house stands between 80 and 90 feet higher than the low-water mark in the river of *Thames*, nearest me; and that part of the river being scarce thirty miles from the sea, I guess (and am more confirmed from some

and to such prodigious distances, that it is a  
great

later experiments I made nearer the sea) that we cannot be much above 100 feet above the sea. The spring I judge nearly level with, or but little higher than where my house stands; and the lands from whence it immediately issues, I guess about 15 or 20 feet higher than the spring; and the lands above that, of no very remarkable height. And indeed, by actual measure, one of the highest hills I have met with in *Effex*, is but 363 feet high (*Vide Phil. Transf. N° 313. p. 16.*) and I guess by some very late experiments I made, neither that, nor any other land in *Effex*, to be above 400 feet above the sea. Now what is so inconsiderable a rise of land to a perennial condensation of vapours, fit to maintain even so inconsiderable a fountain, as what I have mentioned is? or indeed the high-lands of the whole large county of *Effex*, to the maintaining of all its fountains and rivulets?

But I shall no further prosecute this argument, but refer to the late learned, curious and industrious *Dr. Plot's Tentamen Phil. de Orig. Font.* in which he hath fully discussed this matter.

As to the manner how the waters are raised up into the mountains and higher lands, an easy and natural representation may be made of it, by putting a little heap of sand, ashes, or a little loaf of bread, &c. in a basin of water; where the sand will represent the dry land, or an island, and the basin of water the sea about it. And as the water in the basin riseth to, or near the top of the heap in it, so do the waters of the sea, lakes, &c. rise in the hills. Which case I take to be the same with the ascent of liquids in capillary tubes, or between contiguous planes, or in a tube filled with ashes: of which

great wonder the fountains should be high enough (g), or the seas low enough, ever to afford so long a conveyance. Witness the Danube (h) and Wolga of Europe, the Nile (i), and the Niger (k) of Africk, the Ganges (l), and

which the industrious and complete artificer in air-pumps, Mr. *Hawksbee*, hath given us some, not contemptible experiments, in his *Phys. Mech. Exp.* p. 139.

Among the many causes assigned for this ascent of waters, there are two that bid the fairest for it; viz. the Pressure of the Atmosphere, and the Newtonian Attraction. That it is not the former, appears from the experiments succeeding, as well, or better in vacuo, than in the open air, the ascent being rather swifter in vacuo. This then being not the cause, I shall suppose the other is; but for the proof thereof I shall refer to some of our late *English* authors, especially some very late experiments made before our most famous Royal Society, which will be so well improved by some of that illustrious body, as to go near to put the matter out of doubt.

(g) See Book iii. Chap. 4.

(h) 'The *Danube*, in a sober account, performs a course of above 1500 miles (*i. e.* in a strait line) from its rise to its fall.' *Bobun's Geogr. Dict.*

(i) 'Tractus sc. longitudo [*Nili*] est milliarium circiter 630 Germ. five Ital. 2520, pro quibus ponere licet 3000 propter curvaturas.' *Varen. Geogr.* l. 1. c. 16. p. 27.

(k) *Varene* reckons the course of the *Niger*, at a middle computation, 600 *German* miles, that is, 400 *Italian*.

(l) That of the *Ganges* he computes at 300 *German* miles. But if we add the curvatures to these rivers, their channels are of a prodigious length.

and Euphrates of Asia, and the Amazons River (*m*), and Rio de la Plata of America, and many others which might be named; some of which are said to run above 5000 miles, and some no less than 6000 from their fountains to the sea. And indeed such prodigious conveyances of the waters make it manifest, that no accidental currents and alterations of the waters themselves, or art or power of man, nothing less than the Fiat of the Almighty, could ever have made, or found, so long and commodious declivities, and channels for the passage of the waters.

(*m*) ‘Oritur flumen (quod plerumque Amazonum, &c.) haud procul Quito in montibus---  
 ‘Cùm per lucas Hispanicas 1356. cursum ab occidente in orientem continuârit, ostio 84 leucas  
 ‘lato---in oceanum præcipitatur.’ *Cbr. d’Acugna*  
*Relatio de flumine Amaz. in Act. Erud. Aug. 1683.*



## C H A P. VI.

*The great variety and quantity of all things upon, and in the Terraqueous Globe, provided for the uses of the world.*

**T**HE last remark I shall make about the terraqueous globe in general is, the great variety of kinds, or tribes, as well as prodigious number of individuals of each various tribe,

tribe, there is of all creatures (a). There are so many beasts, so many birds, so many insects, so many reptiles, so many trees, so many plants upon the land; so many fishes, sea-plants, and other creatures in the waters; so many minerals, metals, and fossils in the subterraneous regions; so many species of these genera, so many individuals of those species, that there is nothing wanting to the use of man, or any other creature of this lower world. If every age doth change its food,

(a) ‘ Non dat Deus beneficia? Unde ergo ista quæ possides? ---- Unde hæc innumerabilia, oculos, aures & animum mulcentia? Unde illa luxuriam quoque instruens copia? Neque enim necessitatibus tantummodò nostris provisum est: usque in delicias amamur. Tot arbuta, non uno modo frugifera, tot herbæ salutare, tot varietates ciborum per totum annum digestæ, ut inerti quoque fortuita terræ alimenta præberent. Jam animalia omnis generis, alia in sicco, &c.----ut omnis rerum naturæ pars tributum aliquod nobis conferret.’ Senec. *de Benef. l. 4. c. 5. ubi plura vide.*

‘ Hic, ubi habitamus, non intermittit suo tempore cælum nitescere, arbores frondescere-----tum multitudinem pecudum partim ad vescendum, partim ad cultus agrorum, partim ad vehendum, partim ad corpora vestienda; hominemque ipsum quasi contemplatorem cœli ac deorum, ipsorumque cultorem.----Hæc igitur, & alia innumerabilia cùm cernimus, possumusne dubitare, quin his præsit aliquis vel effector, si hæc nata sunt, ut Platoni videtur: vel si semper fuerint, ut Aristoteli placet, moderator tanti operis & muneris.’  
*ic. Tusc. Quæst. l. 1. c. 28, 29.*



food, its way of cloathing, its way of building; if every age (*b*) hath its variety of diseases; nay, if man, or any other animal, was minded to change these things every day, still the creation would not be exhausted, still nothing would be wanting for food, nothing for physick, nothing for building and habitation, nothing for cleanliness and refreshment, yea, even for recreation and pleasure. But the munificence of the Creator is such, that there is abundantly enough to supply the wants, the conveniencies, yea almost the extravagancies of all the creatures, in all places, all ages, and upon all occasions.

And this may serve to answer an objection against the excellency of, and wisdom shewed in, the creation; namely, what need of so many creatures (*c*)? Particularly of so many insects,

(*b*) ‘Sunt & gentium differentiae non mediocres--- quae contemplatio aufert rursus nos ad ipsum forum animalium naturas, ingenitasque iis vel certiores morborum omnium medicinas. Enim vero rerum omnium parens, nullum animal ad hoc tantum ut pasceretur, aut alia fatiaret, nasci voluit: artesque salutes iis inferuerit.’ *Plin. Nat. Hist. l. 27. c. 13.*

(*c*) This was no very easy question to be answered by such as held, ‘That all things were made for man;’ as most of the ancients did; as *Aristotle*, *Seneca*, *Cicero*, and *Pliny*, (to name only some of the chief.) And *Cicero* cites it as the celebrated *Chrysippus*’s opinion, ‘Præclare enim Chrysippus, cætera nata esse hominum causâ, & deorum.’ *De fis.*

fects, so many plants, and so many other things? and especially of some of them that are so far from being useful, that they are very noxious; some by their ferity, and others by their poisonous nature, &c.

To which I might answer, that in great variety, the greater art is seen; that the fierce, poisonous, and noxious creatures serve as rods and scourges to chastise us (*d*), as means to ex-  
cite our wisdom, care, and industry, with more  
to

*bon. & mal. l. 3.* And in his *De Nat. Deor.*  
*2. fin.* he seriously proves the world itself to have been made for the gods and man, and all things in the world to have been made and contrived for the benefit of man ('parata & inventa ad fructum hominum,' are his words.) So *Pliny*, in his preface to his 7th book, saith, nature made all things for man; but then he makes a doubt, whether she new'd herself a more indulgent parent, or cruel step-mother, as in *book iv. chap. 12. note 2.* But since the works of God have been more discovered, and the limits of the universe have been found to be infinitely greater extent than the ancients supposed them; this narrow opinion hath been exploded. And the answer will be found easy to these questions, why so many useless creatures? In the heavens, why so many fixed stars, and the greatest part of them scarce visible? Why such systems of planets, as in *Jupiter, Saturn, &c.* (See my *astro-Theology*.) In the earth and waters, why so many creatures of no use to man?

(*d*) 'Nec minùs clara exitiù documenta sunt etiam ex contemnendis animalibus. M. Varro author est à cuniculis suffossùm in Hispaniâ oppidum, à  
' talpis

to the same purpose. But these things have been fully urged by others; and it is sufficient

‘ talpis in Theſſaliâ : ab ranis civitatem in Galliâ  
 ‘ pulſam, ab locuſtis in Africâ : ex Gyarò Cyclo-  
 ‘ dum inſulâ, incolâs à muribus fugatos : in Italiâ  
 ‘ Amyclas à ſerpentibus deletas. Citra Cynamol-  
 ‘ gos Æthiopas latè deſerta regio eſt à ſcorpionibus  
 ‘ & ſolpugis gente ſublata : & à ſcolopendris abacta  
 ‘ Trerienſes, author eſt Theophraſtus.’ Plin. *Nat.*  
*Hiſt.* l. 8. c. 29.

To theſe inſtances may be added, the plague they ſometimes ſuffer from a kind of mice (they call *Leming, Liminger, Lemmus, &c.*) in *Norway*, which eat up every green thing. They come in ſuch prodigious numbers, that they fancy them to fall from the clouds; but *Ol. Magnus* rather thinks they come from ſome of the iſlands, *Hiſt.* l. 8. c. 2. If the reader hath a mind to ſee a large account of them, with a diſpute about their generation, a handſome cut of them, with the prayers, and an exorcism againſt them uſed in the church of *Rome*, I ſhall refer him (it being too tedious to recite in theſe notes) to *Muſæum Wormian.* l. 3. c. 23.

‘ Quare patimur multa mala à creaturâ quam  
 ‘ fecit Deus, niſi quia offendimus Deum? ---- De  
 ‘ poena tuâ peccatum tuum accuſa, non judicem.  
 ‘ Nam propter ſuperbiam inſtituit Deus creaturam  
 ‘ iſtam minimam & abjectiſſimam ut ipſa nos tor-  
 ‘ queret, ut cùm ſuperbus fuerit homo, & ſe jacta-  
 ‘ verit adverſus Deum, ---cùm ſe erexerit, pulcibus  
 ‘ ſubdatur. Quid eſt, quòd te inflas humanâ ſu-  
 ‘ perbiâ? ---Pulcibus reſiſte ut dormias. Cognosce  
 ‘ qui ſis. Nam propter ſuperbiam noſtram do-  
 ‘ mandam ---creata illa quæ moleſta ſunt. Popu-  
 ‘ lum Pharaonis ſuperbum potuit Deus domare de  
 ‘ Uris,

to say, that this great variety is a most wise provision for all the uses of the world in all ages,

Urfis, &c. Muscas & Ranas illis immisit, ut rebus vilissimis superbia domaretur. Omnia ergo per ipsum---facta sunt; & sine ipso factum est nihil.' August. *Traet. 1. in S. Johan.*

But altho' the infinitely wise Creator hath put it in the power of such vile animals to chastise us, yet hath he shewed no less wisdom and kindness in ordering many, if not most of them so, as that it shall be in the power of man, and other creatures, to obviate or escape their evils. For, besides the noble antidotes afforded by minerals, vegetables, &c. many, if not most of our *European* venomous animals carry their cure, as well as poison in their own bodies. The oil, and, I doubt not, the body of scorpions too, is a certain remedy against its stroke. A Bee, Wasp, or Hornet, crushed and rubbed, and bound upon the place, I have always found to be a certain cure for the sting of those creatures. And I question not, but the flesh, especially the head of vipers, would be found a remedy for their bites.

Our viper catchers have a remedy, in which they place so great confidence, as to be no more afraid of the bite [*of a viper*] than of a common puncture, immediately curing themselves by the application of their specifick. This, though they keep a great secret, I have, upon strict enquiry, found to be no other than *Axungia Viperina*, presently rubbed into the wound.' This remedy the learned Doctor tried himself with good success on a young dog that was bitten in the nose. *Vide Mead Poisons, p. 29.*

And as to the means to escape the mischief of such noxious animals, besides what may be effected by the

ages, and all places : Some for food, some for physick (*e*), some for habitation, some for utensils, some for tools and instruments of work, and some for recreation and pleasure, either to man, or to some of the inferior creatures themselves ; even for which inferior creatures, the liberal Creator hath provided all things necessary, or any ways conducing to their happy com-

the care, industry, and sagacity of man, some of them are so contrived and made, as to give warning or time to creatures in danger from them. Thus, for instance, the Rattle-Snake, the most poisonous of any serpent, who darts its poisonous vapours to some distance, and in all probability was the Basilisk of the ancients, said to kill with its eyes : This involuntarily gives warning by the rattle in its tail. So the Shark, the most rapacious animal of the waters, is forced to turn himself on his back (and thereby gives an opportunity of escape) before he can catch his prey.

(*e*) ‘ Hæc sola naturæ placuerat esse remedia parata vulgo, inventu facilia, ac sine impendio, ex quibus vivimus. Postea fraudes hominum & ingeniorum capturæ officinas invenere istas, in quibus sua cuique homini venalis promittitur vita. Statim compositiones & mixturæ inexplicabiles decantantur. Arabia atque India in medio æstimantur, ulcerique parvo medicina à Rubro mari importatur, cum remedia vera quotidie pauperissimi quisque cænet.’ Plin. *l.* 24. *c.* 1.

‘ Non sponte suâ ex tellure germinant herbes, quæ contra quoscunque morbos accommodæ sunt; sed eæ voluntate opificis, ad nostram utilitatem productæ sunt.’ Basil. *Ascet. Tom.* II.

Consult here, *book* x. *note* (*z*), (*aa*), (*bb*.)

comfortable living in this world, as well as for man.

And it is manifest, that all the creatures of God, beasts, birds, insects, plants, and every other genus, have, or may have their several uses even among men. For, although in one place many things may lie neglected, and out of use, yet in other places they may be of great use. So what hath seemed useless in one age, hath been received in another; as all the new discoveries in physick, and all the alterations in diet do sufficiently witness. Many things also there are which in one form may be pernicious to man; but in another of great use. There are many plants (*f*), many animals,

(*f*) Among poisonous vegetables, none more famous of old than Hemlock, accounted at this day so very dangerous to man, of which there are some dismal examples in our *Phil. Transf. Wepfer, &c.* but yet this plant is food for Goats, and its seeds for Bustards; and, as *Galen* saith, to Starlings also. Neither is this so pernicious a plant only food, but so physick to some animals. An horse troubled with the Farcy, and could not be cured with the most famous remedies, cured himself of it in a short time, by eating Hemlock, of which he eat greedily. *de Phil. Transf. N<sup>o</sup> 231.* And a woman which was cured of the plague, but wanted sleep, did with very good effect eat Hemlock for some time; till falling ill again of a fever, and having left off the use of this remedy, he [*Nic. Fontanus*] endeavoured to procure her rest by repeated doses of Opium, which had no operation, till the help of  
‘*Cicuta*



mals, many minerals, which in one form destroy, in another heal. The *Cassida* plant unprepared poisoneth, but prepared, is the very

‘ *Cicuta* was again called in with desired success.’  
Mead of *Poif.* p. 144.

And not only Hemlock, but many other, if not most plants accounted poisonous, may have their great use in medicine: of which take the opinion of an able judge, my ingenious and learned friend *Dr. Tancred Robinson*, in a letter I have of his to the late great *Mr. Ray*, of *Nov. 7. 1664*; viz. ‘ According to my promise, I here send you a few observations concerning some plants seldom used in medicine, being esteemed poisonous, which if truly corrected, or exactly dosed, may perhaps prove the most powerful and effectual medicines yet known.’ Having then given an account of some of their correctives, he gives these following examples, viz. ‘ The *Hellebores* incorporated with a *Sapo*, or *Alkaly-salts* alone, are successful remedies in epilepsies, vertigo’s, palsies, lethargies and mania’s. Dose one scruple to half a drachm. 2. The *Radic. Affari, Cicutæ*, and the *Napellus* in agues and periodical pains. Dose one scruple to half a drachm. 3. The *Hyoscyamus* in hæmorrhages, violent heats and perturbation of the blood and also in all great inflammations, dose one scruple to half a drachm. 4. The *Semen Stramoniz* is very good anodyne, useful in vigilia’s, rheumatisms, hysterick cases, in all the orgasms of the blood or spirits, and wherever there is an indication for a paregorick, dose one drachm to half a drachm. 5. *Elatarium* thus corrected may be given from gr. x. to xv. in hydropical cases, without any

‘ sensib

very bread of the West-Indies (g). Vipers and scorpions, and many minerals, as destructive as they are to man, yet afford him some of his best medicines.

Or if there be many things of little immediate use to man, in this or any other age, yet to other creatures they may afford food or physick, or be of some necessary use. How many trees and plants, nay, even the very carcasses of animals, yea, the very dust of the earth (b), and the most refuse, contemptible things to be met with; I say, how many such things are either food, or probably medicine to many creatures; afford them retreat, are places of habitation, or matrixes for their generation, as shall

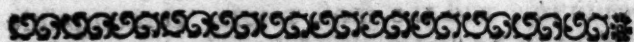
sensible evacuation or disturbance. So may the Soldanella and Gratiola in greater doses. 6. Opium corrected as aforementioned, loses its narcotick faculty, and may be given very safely in great doses, and proves more than usually prevalent in convulsive cases, fluxes, catarrhs, and all painful paroxysms, &c.

(g) 'It is of the most general use of any provision all over the *West-Indies*, especially in the hotter parts, and is used to victual ships.' Dr. Sloane's *at. Hist. of Jamaica*, Vol. I. ch. 5. §. 12.

(b) I have shewn in the *Phil. Transf.* that the *Peculus fatidicus*, *Mortifaga*, *Pulsatorius*, or *Death-watch* there described, feedeth upon dust; but that this dust they eat, is powdered bread, fruits, or such like dust, not powder'd earth; as is manifest from their great diligence and curiosity in hunting among the dust. See more in *Phil. Transf.* N<sup>o</sup> 291.

shall be shewed in proper place? The prodigious swarms of insects in the air, and in the waters (many of which may be perhaps at present of no great use to man) yet are food to birds, fishes, reptiles, insects themselves, and other creatures (i), for whose happy and comfortable subsistence, I have said the bountiful Creator hath liberally provided, as well as for that of man.

(i) See Book iv. Chap. 11.



## B O O K    I I I.

*Of the Terraqueous Globe in particular, more especially the Earth.*

**H**AVING thus taken a general prospect of our terraqueous globe, I shall in this book come to its particulars. But here we have such an immense variety presenting itself to our senses, and such amazing strokes of power and wisdom, that it is impossible not to be at a stand, and very difficult to know where to begin, how to proceed, or where to end. But we must however attempt.

And for the more clear and regular proceeding on this copious subject, I shall distribute the globe into its own grand constituent parts.

I. The Earth and its appurtenances.

II. The Waters and theirs.

The first of these only, is what at present I shall be able to take into this survey.

And

And in surveying the Earth, I intend,

1. To consider its constituent parts, or things peculiar to itself.

2. The inhabitants thereof, or the several kinds of creatures that have their habitation, growth, or subsistence thereon.

1. As to the earth itself, the most remarkable things that present themselves to our view, are,

1. Its various Mould and Soils.

2. Its several Strata, or Beds.

3. Its very subterraneous Passages, Grotto's and Caverns.

4. Its Mountains and Vallies.



## C H A P. I.

### *Of the Soils and Moulds in the Earth.*

**T**HE various soils and moulds are an admirable and manifest contrivance of the all-wise Creator, in making this provision for the various vegetables (a), and divers other uses

(a) It is not to be doubted, that although vegetables delight in peculiar soils, yet they owe not their life and growth to the earth itself, but to some agreeable juices or salts, &c. residing in the earth. Of this the great Mr. Boyle hath given us some good experiments. He ordered his gardener to dig up, and dry in an oven, some earth fit for the purpose, to weigh it, and to set therein some Squash seeds

uses of the creatures. For, as some trees, some plants, some grains dwindle and die in a disagreeable soil, but thrive and flourish in others; so the all-wise Creator hath amply provided for every kind a proper bed.

If some delight in a warm, some in a cold soil; some in a lax or sandy, some a heavy or clayey soil; some in a mixture of both, some in this, and that, and the other mould, some in moist, some in dry places (b), still we find pro-

(a kind of *Indian Pompion*.) The seeds when sown were watered with rain or spring-water only. But although a plant was produced in one experiment of near 3 pound, and in another of above 14 pound, yet the earth when dried, and weighed again, was scarce diminished at all in its weight.

Another experiment he alledges is of *Helmont's*, who dried 200 pounds of earth, and therein planted a willow weighing 5 pound, which he watered with rain, or distilled water: and to secure it from any other earth getting in, he covered it with a perforated tin-cover. After five years, weighing the tree with all the leaves it had born in that time, he found it to weigh 169 pounds, three ounces; but the earth to be diminished only about 2 ounces in its weight. *Vid. Boyle's Scept. Chym. Part. ii. pag. 114.*

(b) Τὰς δὲ τῶν ζῴων τοῦ οἰκείου, ἢ μόνον τὰ περὶ τὰ δένδρων, &c. Τὰ μὲν γὰρ φιλεῖ ξηρὰς, τὰ δὲ ἐνυδρὰς, τὰ δὲ χειμερινὰς, τὰ δὲ προσέχουσιν, τὰ δὲ παλιαινὰς, καὶ ὅλως, τὰ μὲν ὀρεῖνους, τὰ δὲ ἐλώδεις.—Ζητεῖ γὰρ τὰ προσφορὰ κατὰ τὴν κρᾶσιν, ἐτι δὲ ἀσθενῆ, καὶ ἰσχυρὰ, καὶ βαθύρριζα, καὶ ἐπιπολαιόρριζα, καὶ εἴτις ἄλλη διαφορά, κατὰ τὰ μέρη.—Πάντα γὰρ ταῦτα, ἐτι δὲ τὰ ὅμοια ζητεῖ τὸ ὅμοιον, καὶ τὰ ἀνόμοια μὴ τὸν αὐτόν, ὅταν ᾖ τις παραλλαγὴ τῆς φύσεως. THEOPHRAST. de caus. plant. l. 2. c. 9.

provision enough for all these purposes: every country abounding with its proper trees and plants (c), and every vegetable flourishing and gay, somewhere or other about the globe, and abundantly answering the almighty command of the Creator, when the earth and waters were ordered to their peculiar place, *Gen. i. 11.*  
 ‘ And God said, let the earth bring forth  
 ‘ grass, the herb yielding seed, and the tree  
 ‘ yielding fruit after his kind.’ All which we actually see is so.

To this convenience which the various soils that coat the earth are of to the vegetables, we may add their great use and benefit to divers animals, to many kinds of quadrupeds, fowls, insects, and reptiles, who make in the earth their places of repose and rest; their retreat in winter, their security from their enemies, and their nests to repose their young; some delighting in a lax and pervious mould, admitting them an easy passage; and others delighting in a firmer and more solid earth, that will better secure them against injuries from without.

(c) *Nec verò terræ ferre omnes omnia possunt.*

*Fluminibus Salices, crassisque plaudibus Alni*

*Nascuntur; steriles saxosis montibus Orni:*

*Littora Myrtetis lætissima: denique apertos*

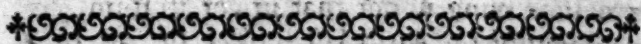
*Bacchus amat colles, Aquilonem & frigora Taxi.*

*Aspice & extremis domitum cultoribus orbem,*

*Eoasque domos Arabum, pictosque Gelonos:*

*Divisa arboribus patriæ, &c. Virg. Georg. l. 2.*





## C H A P. II.

*Of the various Strata, or Beds, observable  
in the Earth.*

**T**HE various Strata, or Beds, although but little different from the last, yet will deserve a distinct consideration.

By the strata, or beds, I mean those layers of minerals (*a*), metals (*b*), earth and stone,

(*a*) Although minerals, metals and stones lie in beds, and have done so ever since *Noah's* flood, if not from the creation; yet it is greatly probable, that they have power of growing in their respective beds: that as the beds are robbed and emptied by miners, so after a while they recruit again. Thus *Vitriol*, Mr. *Boyle* thinks, will grow by the help of the air. So *Alum* doth the same. 'We are assured (he saith) by the experienced *Agricola*, that the earth or ore of *Alum*, being robbed of its salt, will in tract of time recover it, by being exposed to the air.' *Boyle Suspic. about some bid. qual. in the air.* p. 18.

(*b*) As to the growth of metals, there is great reason to suspect that also, from what Mr. *Boyle* hath alledged in his *Observations about the growth of metals*: And in his *Scept. Chym. Part 6. p. 362.* Compare also *Hakewill's Apol. p. 164.*

And particularly, as to the growth of iron, to the instances he gives from *Pliny*, *Fallopianus*, *Cæsalpinus*, and others; we may add, what is well known in the forest of *Dean* in *Gloucestershire*; that the best iron,

stone (c), lying under that upper stratum, or tegument of the earth last spoken of, all of a prodigious use to mankind: some being of great use for building; some serving for ornament, some furnishing us with commodious machines, and tools to prepare our food, and for vessels and utensils, and for multitudes of other uses; some serving for firing to dress our

iron, and most in quantity, that is found there, is in the old cinders, which they melt over again. This the author of the additions to *Gloucestershire*, in *Cambden's Brit.* of the last edition, p. 245, attributes to the remissness of the former melters, in not exhausting the ore: but in all probability, it is rather to be attributed to the new impregnations of the old ore, or cinders, from the air, or from some seminal principle, or plastick quality in the ore itself.

(c) As for the growth of stone, Mr. Boyle gives two instances. One is that famous place in France, called *Les Caves Goutieres*: 'Where the water falling from the upper parts of the cave to the ground, doth presently there condense into little stones of such figure as the drops, falling either severally, or upon one another, and coagulating presently into stones, chance to exhibit.' Vid. *Script. Chym.* p. 360.

Such like caves as these I have myself met with in England; particularly on the very top of *Bredon-hill* in *Worcestershire* near the precipice, facing *Per-shore*, in or near the old fortrefs, called *Benbury-Camp*: I saw some years ago such a cave, which (if I mis-remember not) was lined with those stalactical stones on the top and sides. On the top they hung like icicles great and small, and many lay on the ground.

our food, and to guard us against the insults of cold and weather; some being of great use in physick, in exchange and commerce, in manuring and fertilizing our lands, in dying and colouring, and ten thousand other conveniences, too many to be particularly spoken of: only there is one grand use of one of these strata, or beds, that cannot easily be omitted, and that is, those subterraneous strata of sand, gravel, and laxer earth that admit of, and facilitate

ground. They seemed manifestly to be made by an exsudation, or extillation of some petrifying juices out of the rocky earth there. On the spot, I thought it might be from the rains soaking through, and carrying with it impregnations from the stone, the hill being there all rocky. Hard by the cave is one or more vast stones, which (if I mistake not) are incrustated with this sparry, stalactical substance, if not wholly made of it. But it is so many years ago since I was at the place, and not being able to find my notes about it, I cannot say whether the whole stone is (in all probability) spar (as I think it is) or whether I found it only cased over with it, notwithstanding I was very nice in examining it then, and have now some of the fragments by me, consisting, among other shining parts, of some transparent angular ones.

The other instance of Mr. Boyle, is from *Linschoten*, who saith, that in the *East-Indies*, when they have cleared the diamond-mines of all the diamonds, 'In a few years time they find in the same place new diamonds produced;' Boyle, *ibid*.

cilitate the passage of the sweet waters (*d*), and may probably be the colanders whereby they are sweetened, and then at the same time also convey'd to all parts of the habitable world, not only through the temperate and torrid zones, but even the farthest regions of the frozen poles.

That these strata are the principal passages of the sweet fountain-waters, is, I think, not to be doubted, considering that in them the waters are well known to pass, and in them the springs are found by those that seek for them: I say, the principal passages, because there are other subterraneous guts and channels, fissures and passages, thro' which many times the waters make their way.

Now

(*d*) It is not only agreeable to reason, but I am told by persons conversant in digging of wells throughout this county of *Essex*, where I live, that the surest beds in which they find water, are gravel, and a coarse dark-coloured sand; which beds seldom fail to yield plenty of sweet water: but for clay they never find water therein, if it be a strong, stiff clay; but if it be lax and sandy, sometimes springs are found in it; yet so weak, that they will scarcely serve the uses of the smallest family. And sometimes they meet with those beds lying next under a loose, black mould, (which, by their description, I judge to be a sort of oazy, or to have the resemblance of an ancient, rushy ground) and in that case the water is always naught, and stinks. And lastly, another sort of bed they find in *Essex*, in the clayey lands, particularly that part called the  
*Rodings*,

Now that which in a particular manner doth seem to me to manifest a special providence of God in the repositing these watery beds is, that they should be dispersed all the world over, into all countries, and almost all tracts of land : that they should so entirely, or for the most part, consist of lax, incohering earth, and be so seldom blended with other impervious moulds, or if they are so, it is commonly but accidentally ; and that they are interposed between the other impervious beds, and so are as a prop and pillar to guard them off, and to prevent their sinking in and shutting up the passages of the waters.

The

*Rodings*, which yields plenty of sweet water, and that is a bed of white earth, as tho' made of chalk and white sand. This they find, after they have dug through forty, or more feet of clay ; and it is so tender and moist, that it will not lie upon the spade, but they are forced to throw it into their bucket with their hands, or with bowls ; but when it comes up into the air, it soon becomes an hard white stone.

Thus much for the variety of beds wherein the waters are found. That it is in these beds only or chiefly the springs run, is farther manifest from the forcible eruption of the waters sometimes out of those watry beds. Of which see *chap. 4. note (k)*. This eruption shews that the waters come from some eminence or other, lying at a distance, and being closely pent up within the watry stratum, by the clayey strata, the waters with force mount up, when the strata above are opened.

The time when those strata were laid, was doubtless at the creation, when ' God said, ' (*Gen. i. 9.*) let the waters under the heavens ' be gathered together unto one place, and let ' the dry land appear ; ' or else at the deluge, if, with some sagacious naturalists, we suppose the globe of earth to have been dissolved by the flood (e). At that time (whatever it was) when the terraqueous globe was in a chaotick state, and the earthy particles subsided, then those several beds were, in all probability, re-positied in the earth, in that commodious order in which they now are found ; and that, as is asserted, according to the laws (f) of gravity.

(e) *Vide* Dr. Woodward's Essay, part 2. *Steno's* Prodr. &c.

(f) *Id. ibid.* p. 28, and 74. But Dr. Leigh, in his *Natural History of Lancashire*, speaking of the coal-pits, denies the strata to lie according to the laws of gravitation, saying, the strata are a bed of Marle, afterwards Free-stone, next Iron-stone, then Coal, or Kennel-mine, then some other strata, and again Coal, &c.

But upon a stricter enquiry into the matter, finding I had reason to suspect that few, if any, actually had tried the experiment, I was minded to bring the thing to the test of experiment myself ; and having an opportunity, on *April 11. 1712*, I caused divers places to be bored, laying the several strata by themselves ; which afterwards I weighed with all strictness, first in air, then in water, taking care that no air-bubbles, &c. might obstruct the accuracy of the experiment. The result was,  
that



that in my yard, the strata were gradually specifically heavier and heavier, the lower and lower they went; and the upper, which was clay, was considerably specifically lighter than the lower stratum; which was first a loose sand, then a gravel. In which stratum principally the springs run that supply my well.

But in my fields, where three places were bored (to no great depth) I found below the upper (superficial stratum) a deep bed of sand only, which was of different colours and consistence, which I weighed as before, together with the virgin-mould; but they were all of the same, or nearly the same specific gravity, both out of the same hole, and out of different holes, altho' the sand was at last so gravelly, that it hinder'd our boring any deeper.

Upon this, fearing lest some error might be in the former experiments, I try'd them over again; and that with the same success.

After this, I made some experiments in some deep chalk-pits, with the flints, chalk, &c. above and below; but the success was not so uniform as before.

Acquainting our justly renowned Royal Society with these experiments, they ordered their operator to experiment the strata of a coal-pit; the success whereof may be seen in *Philos. Trans.* N<sup>o</sup> 336.



## C H A P III.

*Of the Subterraneous Caverns and the Vulcano's.*

I Shall take notice of the subterraneous caverns, grotto's and vulcano's, because they are made an objection (a) against the present contrivance and structure of the globe. But, if well considered, they will be found to be wise contrivances of the Creator, serving to great uses of the globe, and ends of God's government. Besides many secret, grand functions and operations of nature in the bowels of the earth, that in all probability these things may minister unto, they are of great use to the countries where they are (b). To instance in the

(a) ' Nemo dixerit terram pulchriorem-esse quòd cavernosa sit, quòd dehiscat in multis locis, quòd disrupta caveis & spatiis inanibus; iisque nullo ordine dispositis, nullâ formâ: nec quæ aliud contineant quàm tenebras & sordes; unde graves & pestiferæ exhalationes, terræ motus, &c.' Burnet *ubi supra*, c. 7.

(b) The Zircbnitzer sea in Carneola, is of great use to the inhabitants of that country, by affording them fish, fowls, fodder, seeds, deer, swine, and other beasts, carriage for their goods, &c. *Vid. Phil. Trans.* N° 191. &c. or *Lowth's Abridg.* Vol. II. p. 306, &c. where you have put together in one view, what is dispersed in divers of the Transactions. This sea or lake proceeds from some subterraneous grotto, or lake, as is made highly probable by Mr. *Valvasor*, *ibid.*

the very worst of the things named, viz. the vulcano's and ignivomous mountains; although they are some of the most terrible shocks of the globe, and dreadful scourges of the sinful inhabitants thereof, and may serve them as emblems, and presages of hell itself; yet even these have their great uses too, being as spiracles or tunnels (c) to the countries where they are, to vent the fire and vapours that would make dismal havock, and oftentimes actually do so, by dreadful succussions and convulsions of the earth. Nay, if the hypothesis of a central fire and waters be true, these outlets seem to be of greatest use to the peace and quiet of the terraqueous globe, in venting the subterraneous heat and vapours; which, if pent up, would make dreadful and dangerous commotions of the earth and waters.

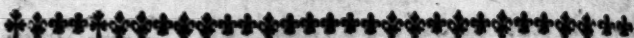
It may be then accounted as a special favour of the divine providence, as is observed by

The *Grotto Podpetschia* may be another instance, that the very subterraneous lakes may be of use, even to the inhabitants of the surface above: of which see *Lowth. ubi sup. p. 317.* *Sturmius* also may be consulted here, in his *Philos. Ecclæs. Exercit. 11. de Terræ mot.* particularly in *chap. 3.* some of the most eminent specus's are enumerated, and some of their uses.

(c) 'Crebri specus [remedium] prebent. Præcon-  
'ceptum enim spiritum exhalant; quòd in certis  
'notatur oppidis, quæ minùs quatiuntur, crebris  
'ad eluviem cuniculis cavata.' *Plin. Hist. Nat.*  
*l. 2. c. 82.*

by the author before praised (d), ' That there are scarcely any countries that are much annoyed with earthquakes, that have not one of these fiery vents. And these (saith he) are constantly all in flames whenever any earthquake happens, they disgorging that fire, which whilst underneath, was the cause of the disaster. Indeed (saith he) were it not for these Diverticula, whereby it thus gaineth an exit, it would rage in the bowels of the earth much more furiously, and make greater havock than now it doth. So that, tho' those countries, where there are such vulcano's, are usually more or less troubled with earthquakes, yet, were these vulcano's wanting, they would be much more annoyed with them than now they are ; yea, in all probability, to that degree, as to render the earth, for a vast space around them, perfectly uninhabitable. In one word (saith he) so beneficial are these to the territories where they are, that there do not want instances of some which have been rescued, and wholly delivered from earthquakes by the breaking forth of a new vulcano there ; this continually discharging that matter, which being till then barricaded up, and imprisoned in the bowels of the earth, was the occasion of very great and frequent calamities.' Thus far that ingenious author.

(d) *Woodward's Essay*, part 3. confect. 13.



## C H A P. IV.

*Of the Mountains and Valleys.*

**T**HE last thing I shall take notice of, relating to the earth, shall be the Hills and Vallies. These the eloquent Theorist owns to 'contain somewhat august and stately in the beholding of them, that inspireth the mind with great thoughts and passions, that we naturally on such occasions think of God and his greatness.' But then, at the same time, he saith, 'the hills are the greatest examples of ruin and confusion; that they have neither form nor beauty, nor shape, nor order, any more than the clouds in the air; that they consist not of any proportion of parts referable to any design, nor have the least footsteps of art or counsel.' Consequently one grand part of this lower creation, even the whole present face of our terraqueous globe, according to this ingenious author, is a work of mere chance, a structure in which the Creator did not concern himself.

Part of this charge I have already briefly answered, and my survey now leads me to shew, that the mountains are so far from being a blunder of chance, a work without design, that they are a noble, useful, yea, a necessary part of our globe (a). And

(a) 'Tho' there are some that think mountains to be a deformity to the earth, &c. yet, if well considered, they will be found as much to conduce

And in the first place, as to the business of ornament, beauty, and pleasure, I may appeal to all mens senses, whether the grateful variety of hills and dales, be not more pleasing than the largest continued plains. Let those who make it their business to visit the globe, to divert their sight with the various prospects of the earth; let these, I say, judge whether the far distant parts of the earth would be so well worth

duce to the beauty and conveniency of the universe, as any of the other parts. Nature (saith *Pliny*) purposely framed them for many excellent uses; partly to tame the violence of greater rivers, to strengthen certain joints within the veins and bowels of the earth; to break the force of the sea's inundation, and for the safety of the earth's inhabitants, whether beasts or men. That they make much for the protection of beasts, the Psalmist testifies, *The highest bills are a refuge for the wild goats, and the rocks for conies.* The kingly prophet had likewise learnt the safety of those by his own experience, when he also was fain to make a mountain his refuge from the fury of his master *Saul*, who persecuted him in the wilderness. True indeed; such places as these keep their neighbours poor, as being most barren, but yet they preserve them safe, as being most strong; witness our unconquered *Wales* and *Scotland*.----- Wherefore a good author doth rightly call them Nature's Bulwarks, cast up at God Almighty's charges, the scorns and curbs of victorious armies; which made the barbarians in *Curius* so confident of their own safety, &c.' *Bishop Wilkins's World in the Moon*, p. 114.



worth visiting, if the earth was every where of an even, level, globous surface, or one large plain of many 1000 miles; and not rather, as now it is, whether it be not far more pleasing to the eye, to view from the tops of the mountains the subjacent vales and streams, and the far distant hills; and again from the vales to behold the surrounding mountains. The elegant strains and lofty flights, both of the ancient and modern poets on these occasions, are testimonies of the sense of mankind on this configuration of the earth.

But be the case as it will as to beauty, which is the least valuable consideration, we shall find as to convenience, this configuration of the earth is far the most commodious on several accounts.

I. As it is the most salubrious, of great use to the preservation or restoration of the health of man. Some constitutions are indeed of so happy a strength, and so confirmed an health, as to be indifferent to any place or temperature of the air: but then others are so weakly and feeble, as not to be able to bear one, but can live comfortably in another place. With some, the finer and more subtile air of the hills doth best agree, who are languishing and dying in the seculent and grosser air of great towns, or even the warmer, and vaporous air of the vallies and waters: but contrarywise others languish on the hills, and grow lusty and strong in the warmer air of the vallies.

So that this opportunity of shifting our abode from the warmer and more vaporous air of the vallies, to the colder and more subtile air of the hills, or from the hills to the vales, is an admirable easement, refreshment, and great benefit to the valetudinarian, feeble part of mankind, affording those an easy and comfortable life, who would otherwise live miserably, languish, and pine away.

2. To this salutary conformation of the earth, we may add another great convenience of the hills, and that is, in affording commodious places for habitation: 'Serving (as an eminent author (*b*) wordeth it) as skreens to keep off the cold and nipping blasts of the northerly and easterly winds, and reflecting the benign and cherishing sun-beams, and so rendering our habitations both more comfortable and more chearly in winter; and promoting the growth of herbs and fruit-trees, and the maturation of the fruits in summer.'

3. Another benefit of the hills is, that they serve for the production of great varieties of herbs and trees (*c*). And as there was not a better judge of those matters, so I cannot give a better account of this convenience, than in the

(*b*) *Ray's Wisdom of God, &c.* p. 251. *Dissolution of the world,* p. 35.

(*c*) *Theophrastus* having reckoned up the trees that delight most in the hills, and others in the valleys, obser-

the words of the last cited famous author, the late most eminent and learned Mr. Ray (*d*), (who hath so fully discussed this subject I am upon, that it is scarce possible to tread out of his steps therein.) His observation is, ‘ That  
 ‘ the mountains do especially abound with  
 ‘ different species of vegetables, because of  
 ‘ the great diversity of soils that are found  
 ‘ there, every vertex, or eminence almost,  
 ‘ affording new kinds. Now these plants  
 ‘ (saith he) serve partly for the food and sus-  
 ‘ tenance of such animals as are proper to the  
 ‘ mountains, partly for medicinal uses; the  
 ‘ chief physick-herbs and roots, and the best  
 ‘ in their kinds growing there: It being  
 ‘ remarkable, that the greatest and most luxu-  
 ‘ rious species in most genera of plants are  
 ‘ natives of the mountains.

4. Another convenience which my last named learned friend observes (*e*) is, That  
 ‘ the mountains serve for the harbour, en-  
 ‘ tertainment, and maintenance of various  
 ‘ animals, birds, beasts and insects, that breed,  
 ‘ feed, and frequent there. For (saith he)  
 ‘ the

observeth, “Απαντα δὲ ὅσα κοινὰ τῶν ὄρεων καὶ τῶν πεδίων, μείζω μὲν καὶ καλλίω τῇ ὀφεί τὰ ἐν τοῖς πεδίοις γίνεται· κρείττω δὲ τῆτε χρῆσται τῶν ξύλων καὶ τῶν καρπῶν, τὰ ὄρευνα. Theoph. Hist. Pl. l. 3. c. 4. “Απαντα δὲ ἐν τοῖς οἰκαίοις τόποις καλλίω γίνεται, καὶ μᾶλλον εὐσθενεῖ.—Τὰ μὲν γὰρ φιλεῖ τὰς ἐφύδρας καὶ ἐλώδεις, —τὰ δὲ τὰς εὐσκαπέεις καὶ εὐήλιος, Ib. l. 4. c. 1.

(*d*) *Wisdom of God*, p. 352.

(*e*) *Ubi supra*.

‘ the highest tops and pikes of the Alps themselves are not destitute of their inhabitants, the Ibex or Stein-buck, the Rupicapra or Chamois, among quadrupeds; the Lagopus among birds. And I myself (saith he) have observed beautiful Papilio’s, and store of other insects upon the tops of some of the Alpine mountains. Nay, the highest ridges of many of these mountains serve for the maintenance of cattle, for the service of the inhabitants of the valleys.’

5. Another thing he observes is, ‘ That those long ridges and chains of lofty and topping mountains, which run through whole continents east and west (f), serve to stop the evagation of the vapours to the north and south in hot countries, condensing them like alembick-heads into water, and so (according to his opinion) by a kind of external distillation giving original to springs and rivers; and likewise by amassing, cooling

(f) Many have taken notice, that some of the greatest eminences of the world run generally east and west; of which, take the late ingenious and learned Dr. *Nichols’s* account, [*Confer. with a Theist*, Part 2. p. 191.] ‘ To go no farther than our own country, all our great ridges of hills in *England* run east and west; so do the *Alps* in *Italy*, and in some measure the *Pyrenees*; so do the mountains of the moon in *Africk*, and so do mount *Taurus* and *Caucasus*. This (he saith) is a wise contrivance to prevent the vapours, which would all run northwards, and leave no rains in the *Mediterranean* countries.’

‘ing and conſtipating of them, turn them into  
 ‘rain, by thoſe means rendering the fervid  
 ‘regions of the torrid zone habitable.’

To theſe might be added ſome other uſes  
 and conveniences (g); as that the hills ſerve  
 to the generation of minerals and metals (h),  
 and that in them principally are the moſt uſe-  
 ful foſſiles found; or if not found and gene-  
 rated

(g) That the generation of many of the clouds is  
 owing to the hills, appears from the obſervations  
 of the ingenious and learned Dr. *Job. Jam. Scheuch-*  
*zer* of *Zurich*, and Mr. *Joach. Frid. Crellowius* cited  
 by him. They obſerv’d at ſun-riſing, divers clouds  
 detach’d by the heat of the ſun, from ſome of the  
 tops of the *Alps*, &c. upon all which their obſerva-  
 tions, the concluſion is, ‘Mirati ſummam Creato-  
 ‘ris ſapientiam, qui & id quod paulò antè nulli  
 ‘nobis uſui eſſe videbatur, maximis rebus deſtina-  
 ‘verat, adeòque ex illo tempore dubitare cœpi,  
 ‘num nubes eſſent futuræ, ſi iſtiusmodi montes &  
 ‘petræ non darentur. Hypotheſi hæc ſtante, elu-  
 ‘ceſceret permagna utilitas, imò neceſſitas, quam  
 ‘*Helveticæ Alpes* non nobis tantum accolis, ſed &  
 ‘vicinis aliis regionibus præſtant, diſpenſando, quas  
 ‘gignunt nubes, ventos, aquas.’ Scheuch. *Iter*.  
*Alpin.* 2. p. 20.

(h) Let us take here *Ol. Mag.* obſervation of his  
 northern mountains; ‘Montes excelsi ſunt, ſed  
 ‘pro majori parte ſteriles, & aridi; in quibus ſerè  
 ‘nil aliud pro incolarum commoditate & conſer-  
 ‘vatione gignitur, quàm inexhauſta pretioſorum  
 ‘metallorum ubertas, quâ ſatis opulenti, fertiles-  
 ‘que ſunt in omnibus vitæ neceſſariis, forſitan &  
 ‘ſuperfluis aliunde ſi libet conquirendis, unanimi-  
 ‘que



rated only in them, yet at least all these subterraneous treasures are most easily come at in them : Also their use to several nations of the earth, in being boundaries and bulwarks to them. But there is only one use more that I shall insist on ; and that is,

6. And lastly, that it is to the hills that the fountains owe their rise, and the rivers their conveyance. As it is not proper, so neither shall I here enter into any dispute about the origin of springs, commonly assign'd by curious and learned philosophers. But whether their origin be from condensed vapours, as some think (i) ; or from rains falling, as others ; or whether they are derived from the sea by way of attraction, percolation, or distillation ; or whether all these causes concur, or only some, still the hills are the grand agent in this prodigious benefit to all the earth : those vast masses and ridges of earth serving as so many huge Alembicks or Cola in this noble work of nature.

But be the *modus*, or the method nature takes in this great work, as it will, it is sufficient to my purpose, that the hills are a grand agent in this so noble and necessary a work : and consequently, that those vast masses and lofty

“ que robore, ac viribus, ubi vis contra hæc naturæ dona intentata fuerit, defendendis. Acre  
 “ enim genus hominum est. &c.” *Ol. Mag. Hist.*  
*l. 6. Pref.* See also Sir Robert Sibbald's *Prodr. Nat. Hist. Scot.* p. 47.

(i) See book i. chap. 3. note (b).



lofty piles are not, as they are charged, such rude and useless excrescences of our ill-formed globe ; but the admirable tools of nature, contrived and ordered by the infinite Creator, to do one of its most useful works, and to dispense this great blessing to all parts of the earth ; without which neither animals could live, nor vegetables scarcely grow, nor perhaps minerals, metals, or fossiles receive any increase. For was the surface of the earth even and level, and the middle parts of its islands and continents not mountainous and high (as now it is) it is most certain there could be no descent for the rivers, no conveyance for the waters ; but instead of gliding along those gentle declivities which the higher lands now afford them, quite down to the sea, they would stagnate, and perhaps stink, and also drown large tracts of land.

But indeed, without hills, as there could be no rivers, so neither could there be any fountains, or springs about the earth ; because, if we could suppose a land could be well watered (which I think not possible) without the higher lands, the waters could find no descent, no passage thro' any commodious out-lets, by virtue of their own gravity ; and therefore could not break out into those commodious passages and currents, which we every where almost find in, or near the hills, and seldom or never, in large and spacious plains ; and when we do find 'em in them, it is generally at great and inconvenient depths of the earth ; nay, those very subterraneous waters, that are any where met

met with by digging in these plains, are in all probability owing to the hills, either near or far distant : As among other instances may be made out, from the forcible eruption of the subterraneous waters in digging wells, in the Lower Austria, and the territories of Modena, and Bologna in Italy, mentioned by my fore-named learned Friend Mr. Ray (k). Or if there be any such place found throughout the earth, that is devoid of mountains, and yet well

(k) ‘ Monsieur *Blundel* related to the Parisian Academy, what device the inhabitants of the Lower Austria (which is encompassed with the mountains of *Stiria*) are wont to use to fill their wells with water. They dig in the earth to the depth of 20 and 25 feet, till they come to an Argilla [clammy earth]--- which they bore through so deep, till the waters break forcibly out; which water, it is probable, comes from the neighbouring mountains in subterraneous channels. And *Cassinus* observed, that in many places of the territory of *Modena* and *Bologna* in *Italy*, they make themselves wells by the like artifice, &c. By these means the same Seig. *Cassini* made a fountain at the castle of *Urbino*, that cast up the water 5 foot high above the level of the ground,’ Ray’s *Disc.* p. 40. ubi plura.

Upon enquiry of some skilful workmen, whose business it is to dig wells, &c. whether they had ever met with the like case as these in this note; they told me they had met with it in *Essex*, where after they had dug to 50 feet depth, the man in the well observed the clayey bottom to swell and

well watered, as perhaps some small islands may ; yet in this very case, that whole mass of land is no other than as one mountain descending (tho' unperceivedly) gently down from the mid-land parts to the sea, as most other lands do ; as is manifest from the descent of their rivers, the principal of which in most countries, have generally their rise in the more lofty mid-land parts.

And now considering what hath been said concerning this last use of the hills, there are two or three acts of the divine providence observable therein. One is, that all countries throughout the whole world should enjoy this great benefit of mountains, placed here and there, at due and proper distances, to afford the several nations this excellent and most necessary element the waters. For, according to nature's tendency, when the earth and waters were separated, and order'd to their several places, the earth must have been of an even surface, or nearly so. The several component parts of the earth must have subsided according to their several specifick gravities, and

begin to send out water, and stamping with his foot to stop the water, he made way for so sudden and forcible a flux of water, that before he could get into his bucket, he was above his waist in water ; which soon ascended to 17 feet height, and there stayed : and although they often, with great labour endeavoured to empty the well, in order to finish their work, yet they could never do it, but were forced to leave it as it was.

and at last have ended in a large, even, spherical surface, every where equidistant from the centre of the globe: But that instead of this form, so incommodious for the conveyance of the waters, it should be jetted out every where into hills and dales, so necessary for that purpose, is a manifest sign of an especial providence of the wise Creator.

So another plain sign of the same especial providence of God, in this matter, is, that generally throughout the whole world, the earth is so dispos'd, so order'd, so well laid, I may say, that the mid-land parts, or parts farthest from the sea, are commonly the highest: which is manifest, I have said, from the descent of the rivers. Now this is an admirable provision the wise Creator hath made for the commodious passages of the rivers, and for draining the several countries, and carrying off the superfluous waters from the whole earth, which would be as great an annoyance, as now they are a convenience.

Another providential benefit of the hills supplying the earth with water, is, that they are not only instrumental thereby, to the fertility of the valleys, but to their own also (1); to the

(1) As the hills being higher, are naturally disposed to be drier than the valleys; so kind nature hath provided the greater supplies of moisture for them, such at least of them as do not ascend above the clouds and vapours. For, besides the fountains continually watering them, they have more dews

the verdure of the vegetables without, and to the increment and vigor of the treasures within them.

Thus having vindicated the present form and fabrick of the earth, as distributed into mountains and valleys, and thereby shewn in some measure the use thereof, particularly of the mountains, which are chiefly found fault with ; I have, I hope, made it in some measure evident, that God was no idle spectator (*m*) nor unconcerned in the ordering of the terraqueous globe, as the former bold charges against it do infer ; that he did not suffer so grand a work as the earth, to go unfinished out of his Almighty hand ; or leave it  
to

and rains commonly than the valleys. They are more frequently covered with fogs ; and by retarding, stopping, or compressing the clouds, or by their greater colds condensing them, they have larger quantities of rain fall upon them. As I have found by actual experience, in comparing my observations with those of my late very curious and ingenious correspondent, *Richard Townly*, Esq; of *Lancashire*, and some others, to be met with before, chap. 2. note (*a*). From which it appears, that above double the quantity of rain falleth in *Lancashire*, than doth at *Upminster* : The reason of which is, because *Lancashire* hath more, and much higher hills than *Essex* hath. See book ii. chap. 5. note (*e*).

(*m*) ‘ Accusandi sanè meâ sententiâ hic sunt Sophistæ, qui cùm nondum invenire, neque exponere opera naturæ queant, eam tamen inertiam atque inscitiam condemnant, &c. Galen. *ne us. part.* l. 10. c. 9.



to be order'd by chance, by natural gravity, by casual earthquakes, &c. but that the noble strokes, and plain remains of wisdom and power therein, do manifest it to be his work. That particularly the hills and vales, tho' to a peevish weary traveller they may seem inconvenient and troublesome; yet are a noble work of the great Creator, and wisely appointed by him for the good of our sublunary world.

And so for all the other parts of the terraqueous globe that are presumed to be found fault with by some, as if carelessly order'd, and made without any design or end; particularly the distribution of the dry land and waters: the laying the several strata, or beds of earth, stone, and other layers before spoken of, the creation of noxious animals; and poisonous substances, the boisterous winds; the vulcano's, and many other things which some are angry with, and will pretend to amend; I have before shewn, that an infinitely wise providence, an Almighty hand was concerned even in them; that they have all their admirable ends and uses, and are highly instrumental and beneficial to the being, or well-being of this our globe, or to the creatures residing thereon.

So also for human bodies, it hath been an ancient (*n*), as well as modern complaint, that  
our

(*n*) 'Vide quàm iniqui sint divinatorum munerum  
' æstimatores, etiam quidam professi sapientiam.  
' Queruntur quòd non magnitudine corporis aque-



our bodies are not as big as those of other animals ; that we cannot run as swift as deer, fly like birds, and that we are out-done by many creatures in the accuracy of the senses, with more to the same purpose. But these objections are well answered by Seneca (o), and will receive a fuller solution from what I shall observe of animal bodies hereafter.

But

‘ mus elephantes, velocitate cervos, levitate aves,  
 ‘ impetu tauros ; quod solidior sit, cutis belluis, de-  
 ‘ centior damis, densior urfis, mollior fibris ; quòd  
 ‘ sagacitate nos narium canes vincant, quòd acie  
 ‘ luminum aquilæ, spatio ætatis corvi, multa ani-  
 ‘ malia nandi facilitate. Et cùm quædam nè coire  
 ‘ quidem in idem natura patiatur, ut velocitatem  
 ‘ corporis & vires pares animalibus habeamus ; ex  
 ‘ diversis & dissidentibus bonis hominem non esse  
 ‘ compositum, injuriam vocant ; & in negligentes  
 ‘ nostri deos querimoniam jaciunt, quòd non bona  
 ‘ valetudo ; & vitiis inexpugnabilis data sit, quòd  
 ‘ non futuri scientia. Vix sibi temperant quin  
 ‘ eousque impudentiæ provehantur, ut naturam o-  
 ‘ derint, quòd infra deos sumus, quòd non in æquo  
 ‘ illis stetimus.’ Seneca, *de benef. lib. 2. cap. 29.*

(o) ‘ Quanto satiùs est ad contemplationem tot  
 ‘ tantorumque beneficiorum reverti, & agere gra-  
 ‘ tias, quòd nos in hoc pulcherrimo domicilio vo-  
 ‘ luerunt [Dii] secundos fortiri, quod terrenis præ-  
 ‘ fecerunt.’ Then having reckoned up many of  
 the privileges and benefits, which the gods, he saith,  
 have conferred upon us, he concludes, ‘ Ita est :  
 ‘ carissimos nos habuerunt dii immortales, habent-  
 ‘ que. Et qui maximus tribui honos potuit, ab  
 ‘ ipsis proximos collocaverunt. Magna accepimus,  
 ‘ majora non cepimus.’ Senec, *ibid.*

But indeed, after all, it is only for want of our knowing these things better, that we do not admire (p) them enough ; it is our own ignorance, dulness, or prejudice, that makes us charge those noble works of the Almighty, as defects or blunders, as ill-contrived, or ill-made.

It is therefore fitter for such finite, weak, ignorant beings as we, to be humble and meek, and conscious of our ignorance, and jealous of our own judgment, when it thus confronteth infinite wisdom. Let us remember how few things we know, how many we err about, and how many we are ignorant of : and those, many of them, the most familiar, obvious things : things that we see and handle at pleasure ; yea, our own very bodies, and that very part of us whereby we understand at all, our soul. And should we therefore pretend to censure what God doth ! should we pretend to amend his work ! or to advise infinite wisdom ! or to know the ends and purposes of his infinite will, as if we were of his council ! no, let us bear in mind, that these objections are the products, not of reason, but of peevishness. They have been incommoded by storms and tempests ; they have been terrify'd with the burning mountains, and earthquakes ; they have been annoyed by the noxious animals, and fatigued by the hills ; and therefore

(p) ' Naturam maximè admiraberis, si omnia  
ejus opera perlustrâris.' Galen. *de us. part. l.*  
11. *conclus.*

fore are angry, and will pretend to amend these works of the Almighty. But in the words of St. *Paul* (g), we may say, 'Nay, but O man, who art thou that repliest against God? Shall the thing formed say to him that formed it, Why hast thou made me thus? Hath not the potter power over the clay, of the same lump to make one vessel to honour, and another to dishonour?' If the almighty Lord of the world had, for his own pleasure, made this our world more inconvenient for man, it would better become us to sit still, and be quiet; to lament our own great infirmities and failings, which deserve a worse place, a more incommodious habitation than we meet with in this elegant, this well-contrived, well-formed world; in which we find every thing necessary for the sustentation, use, and pleasure, both of man, and every other creature here below; as well as some whips, some rods to scourge us for our sins (r). But yet so admirably well temper'd is our state, such an accord, such an harmony

15

(g) Rom. ix. 20, 21.

(r) 'Neither are they [noxious creatures] of less use to amend our minds, by teaching us care and diligence, and more wit. And so much the more, the worse the things are we see, and should avoid. Weefels, Kites, and other mischievous animals, induce us to a watchfulness: Thistles and Moles to good husbandry; Lice oblige us to cleanliness in our bodies; Spiders in our houses; and the Meth in our clothes. The deformity and filthi-

ness

is there throughout the creation, that if we will but pursue the ways of piety and virtue, which God hath appointed; if we will form our lives according to the Creator's laws, we may escape the evils of this our frail state, and find sufficient means to make us happy whilst we are in the body. The natural force and tendency of our virtue, will prevent many of the harms (s), and the watchful providence of our Almighty Benefactor will be a guard against others; and then nothing is wanting to make us happy, as long as we are in this world, there being abundantly enough to entertain the minds of the most contemplative; glories enough to please the eye of the most curious and inquisitive; harmonies and consorts of nature's own, as well as man's making, sufficient

'ness of Swine, make them the beauty-spot of the  
'animal creation, and the emblems of all vice.---  
'The truth is, things are hurtful to us only by ac-  
'cident; that is, not of necessity, but through our  
'own negligence or mistake. Houses decay, corn  
'is blasted, and the weefel breeds in malt, soonest  
'towards the south. Be it so, it is then our own  
'fault, if we use not the means which nature and  
'art have provided against these inconveniences.'  
Grew's *Cosmol. chap. 2. § 49, 50.*

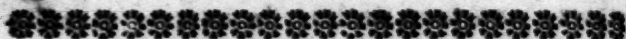
(s) *Non est gemendus, nec gravi urgendus nece.*  
*Virtute quisquis abstulit fatis iter.*

*Senec. Hercul. Oet. act. 5. car. 1833.*

*Nunquam stygias fertur ad umbras*  
*Inchyta virtus.*

*Id. ibid. car. 1982*

cient to delight the ear of the most harmonious and musical; all sorts of pleasant gusts to gratify the taste and appetite, even of the most luxurious; fragrant odours, to please the nicest and tenderest smell: And, in a word, enough to make us love and delight in this world, rather too much, than too little, considering how nearly we are ally'd to another world, as well as this.



## B O O K IV.

### *Of Animals in general.*

**I**N the last book, having survey'd the earth itself in particular, I shall next take a view of the inhabitants thereof; or the several kinds of creatures (a), that have their habitation, growth, or subsistence thereon.

These creatures are either sensitive, or insensitive creatures.

In speaking of those endowed with sense, I shall consider,

I. Some

- (a) *Principio caelum, ac terras, camposque liquentes,  
Lucentemque globum Lunæ, Titaniaque astra  
Spiritus intus alit, totamque infusa per artus  
Mens agitat molem, & magno se corpore miscet.  
Inde hominum, pecudumque genus, vitæque volantum,  
Et quæ marmoreo fert monstra sub æquore pontus,  
Igneus est illis vigor, & cælestis origo  
Seminibus.*

*Virg. Æneid. l. 6. carm. 724.*

I. Some things common to them all.

II. Things peculiar to their tribes.

I. The things in common, which I intend to take notice of, are these ten :

1. The five senses, and their organs.

2. The great instrument of vitality, Respiration.

3. The Motion, or loca-motive faculty of animals.

4. The Place in which they live and act.

5. The Balance of their numbers.

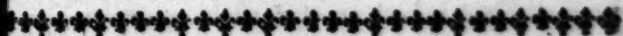
6. Their Food.

7. Their Cloathing.

8. Their Houses, Nests or Habitations.

9. Their methods of Self-preservation.

10. Their Generation, and Conservation of their species by that means.



## CHAP. I.

### *Of the Five Senses in general.*

THE first thing to be consider'd, in common to all the sensitive creatures, is, their faculty of Seeing, Hearing, Smelling, Tasting and Feeling; and the organs ministering to these five senses, together with the exact accommodation of those senses, and their organs, to the state and make of every tribe of animals (a). The consideration of which

par-

(a) ' Ex sensibus ante cætera homini tactus, deinde Gustatus : reliquis superatur à multis. Aquila



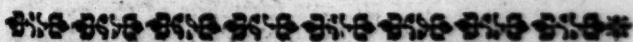
particulars alone, were there no other demonstrations of God, is abundantly sufficient to evince the infinite wisdom, power and goodness of the great Creator. For, who can but stand amazed at the glories of these works! at the admirable artifice of them! and at their noble use and performances! For suppose an animal, as such, had breath and life, and could move itself hither and thither; yet how could it know whither to go, what it was about, where to find its food, how to avoid thousands of dangers (*b*), without sight! How could man, particularly, view the glories of the heavens, survey the beauties of the fields, and enjoy the pleasure of beholding the noble variety of diverting objects, that do, above us in the heavens, and here in this lower world, present themselves to our view every where; how enjoy this, I say, without that admirable sense of sight (*c*)! How could also the animal, without smell and taste, distinguish its food, and discern between wholesome and unwholesome:

‘ læ clariùs cernunt: Vultures sagaciùs odorantur  
 ‘ liquidiùs audiunt Talpæ obrutæ terrâ, tam den-  
 ‘ so atque surdo naturæ elemento.’ Plin. nat. hist.  
 l. 10. c. 69.

(*b*) ‘ Subjacent oculi, pars corporis pretiosissima  
 ‘ & qui lucis usu vitam distinguant à morte.’ Plin.  
 Nat. hist. l. 11. c. 37.

(*c*) ‘ Fœminæ aliquæ Megarenses solis oculis  
 ‘ scernere valebant inter ova quæ ex Gallinâ nigra  
 ‘ & quæ ex albâ nata sunt,’ is what is affirmed  
 (how truly I know not) by Grimald, de lumin,  
 color. pr. 43. § 60,

wholsome ; besides the pleasures of delightful odours, and relishing gusto's ! How, without that other sense of hearing, could it discern many dangers that are at a distance, understand the mind of others, perceive the harmonious sounds of musick, and be delighted with the melodies of the winged choir, and all the rest of the harmonies the Creator hath provided for the delight and pleasure of his creatures ! And lastly, how could man, or any other creature, distinguish pleasure from pain, health from sickness, and consequently be able to keep their body sound and entire, without the sense of feeling ! Here, therefore, we have a glorious oeconomy in every animal, that commandeth admiration, and deserveth contemplation : as will better appear by coming to particulars, and distinctly considering the provision which the Creator hath made for each of these senses.



## C H A P. II.

*Of the EYE.*

**F**OR our clearer proceeding in the consideration of this noble part (a), and understanding its oeconomy, I shall consider,

## 1. The

(a) ' In dissectionibus anatomicis vix aliquid admirabilius, aut artificiosius structurâ oculi humani, meo quidem judicio, occurrit : ut meritò, per excellentiam, Creatoris appelletur miraculum.'

Gul. Fabr. Hildan. Cent. 2. observ. 1.

1. The Form of the eye.
2. Its Situation in the body.
3. Its Motions.
4. Its Size.
5. Its Number.
6. Its Parts.
7. The Guard and Security nature hath provided for this so useful a part.

As this eminent part hath not been pretermitted by authors that have made it their particular design and business to speak of the works of God ; so divers of the aforesaid particulars have been touched upon by them. And therefore I shall take in as little as possible of what they have said, and as near as I can, mention chiefly what they have omitted. And,

1. For the Form of the eye ; which is for the most part globous, or somewhat of the sphae-

So likewise that curious surveyor of the eye, Dr. *Briggs*, whose *Ophthalmography* I have met with since my penning this part of my survey. His character of this curious-piece of God's work is, ' *Inter præcipuas corporis animati partes, quæ magni conditoris nostri sapientiam ostendunt, nulla sanè reperitur, quæ majori pompâ elucet quàm ipse oculus, aut quæ elegantiori formâ concinnatur. Dum enim aliæ partes vel minori satellitio stipantur, vel in tantam venustatem haud assergunt ; ocelli peculiarem honorem & decus à supremo numine afflatum referunt, & nunquam non stupendæ suæ potentiae characteres representant. Nulla sanè pars tam divino artificio & ordine, &c.* Chap. 1. § 1.

spheroidal form, which is far the more commodious optical form, as being fittest to contain the humours within, and to receive the images of objects from without (*b*). Was it a cube, or of any multangular form, some of its parts would lie too far off (*c*), and some too nigh those lenticular humours, which by their

(*b*) It is good reason Friar *Bacon* assigns for the sphericity of the eye: 'Nam si esset planæ figuræ, species rei majoris oculo non posset cadere perpendiculariter super eum---Cum ergo oculus videt magna corpora, ut serè quartam coeli uno aspectu, manifestum est, quòd non potest esse planæ figuræ, nec alicujus nisi sphæricæ, quoniam super sphæram parvam possunt cadere perpendiculares infinitæ, quæ à magno corpore veniunt, & tendunt in centrum sphære: Et sic magnum corpus potest ab oculo parvo videri.' For the demonstration of which he hath given us a figure. *Reg. Bacon. Perspect. distinct. 4. cap. 4.*

Dr. *Briggs* saith, 'Pars antica (five cornea) convexior est posticâ: hâc enim ratione radii meliùs in pupillam detorquentur, & oculi fundus ex alterâ parte in majorem (propter imagines rerum ibidem delineandas) expanditur.' *Ibid. § 2.*

(*c*) Suppose the eye had the Retina, or back part, flat for the reception of the images, as in *fig. 1. ABA*; it is manifest, that if the extremes of the image *AA* were at a due focal distance, the middle *B* would be too nigh the crystalline, and consequently appear confused and dim; but all parts of the retina lying at a due focal distance from the crystalline, as at *ACA*, therefore the image painted thereon is seen distinct and clear. Thus in a dark room,

their refractions cause vision. But by means of the form before-mentioned, the humours of the eye are commodiously laid together, to perform their office of refraction ; and the retina, and every other part of that little darken'd cell, is neatly adapted regularly to receive the images from without, and to convey them accordingly to the commonly sensory in the brain.

To this we may add the aptitude of this figure to the motion of the eye ; for as it is necessary for the eye to move this way, and that way, in order to adjust itself to the objects it would view ; so by this figure it is well prepared for such motions, so that it can with great facility and dexterity direct itself as occasion requires.

And as the figure, so no less commodious is,

2. The Situation of the eye ; namely, in the head (*d*), the most erect, eminent part of the body, near the most sensible, vital part, the brain. By its eminence in the body, it

is

room, with a lens at a hole in the window (which *Sturm* calls his artificial eye, in his *Exercit. Acad.* one of which he had made for his pupils, to run any where on wheels). In this room, I say, if the paper that receives the images be too nigh, or too far off the lens, the image will be confused and dim ; but in the focus of the glass, distinct, clear, and a pleasant sight.

(*d*) ‘ Blemmyis traduntur capita abesse, ore & oculis pectore affixis.’ *Plin. Nat. hist. l. 5. c. 28.*

‘ Occidentem versus quosdam sine cervice oculos in humeris

is prepar'd to take in the more (e) objects. And by its situation in the head, besides its proximity to the brain, it is in the most convenient place for defence and security. In the hands, it might indeed (in man) be render'd more eminent than the head, and be turned about here and there at pleasure: but then it would be expos'd to many injuries in that active part, and the hands (f) render'd a less active and useful part. And the like may be said to its sight, in any other part of the body, but where it is. But in the head, both of man, and other animals, it is placed in a part that seems to be contriv'd and made, chiefly for the action of the principal senses.

Another thing observable in the sight of the eye, is the manner of its situation in the head, in the fore-part, or side-part thereof, according to the particular occasions of particular animals. In man, and some other creatures, it is placed to look directly forward chiefly; but

'humeris habentes.' *Ib. l. 7. c. 2.* From these, and other such like fables, in this last cited chapter of *Pliny*, no doubt our famous romancer *Sir J. Mandeville*, had his romantick stories related in his travels.

(e) See *book v. chap. 2. note (e).*

(f) *Galen* deserves to be here consulted, who in his book *De usu partium*, from many considerations of the hand, such as what is here mentioned, as also its structure, site and use, largely proves and reflects upon the wisdom and providence of the contriver and maker of that part.



but withal it is so order'd, as to take in near the hemisphere before it. In birds, and some other creatures, the eyes are so seated, as to take in near a whole sphere, that they may the better seek their food, and escape dangers. And in some creatures they are seated so as to see best behind them (g), or on each side, whereby they are enabled to see their enemy that pursues them that way, and so make their escape.

And for the assistance of the eyes, and some of the other senses in their actions, the head is generally made to turn here and there, and move as occasion requires. Which leads me to the

3. Thing to be remarked upon, the Motions of the eye itself. And this is generally upwards, downwards, backwards, forwards, and every way (b) for the better, more easy, and distinct reception of the visual rays.

But where nature any way deviateth from this method, either by denying motion to the  
eyes,

(g) Thus in Hares and Conies, their eyes are very protuberant, and placed so much towards the sides of their head, that their two eyes take in nearly a whole sphere: whereas in dogs (that pursue them) the eyes are set more forward in the head, to look that way more than backward.

(b) 'Sed lubricos oculos fecit [natura] & mobiles, ut & declinarent siquid noceret; & aspectum, quo vellent, facile converterent.' Cicer. *de nat. deor.* l. 2. c. 57.

(i) 'The eyes of Spiders (in some four, in some six, and in some eight) are placed all in the forefront of their head (which is round, and without  
any

eyes, or the head (i), it is a very wonderful provision she hath made in the case. Thus for a remedy of this inconvenience, in some crea-

‘ any neck) all diaphanous and transparent, like a  
 ‘ locket of diamonds, &c. neither wonder why  
 ‘ providence should be so anomalous in this animal,  
 ‘ more than in any other we know of. For, 1. Since  
 ‘ they wanting a neck, cannot move their head, it is  
 ‘ requisite that defect should be supplied by the mul-  
 ‘ tiplicity of eyes. 2. Since they were to live by  
 ‘ catching so nimble a prey as a fly is, they ought  
 ‘ to see her every way, and to take her *per saltum*  
 ‘ (as they do) without any motion of the head to  
 ‘ discover her: which motion would have scared  
 ‘ away so timorous an insect.’ Power’s *Microsc.*  
*observ. p. 11.*

‘ The eyes of the Cameleon resemble a lens, or  
 ‘ convex-glass, set in a versatile globular socket,  
 ‘ which she turneth backward or any way, with-  
 ‘ out moving her head; and ordinarily the one a  
 ‘ contrary or quite different way from the other.’  
*Dr. Goddard in Phil. Trans. N° 137.*

‘ But what is more extraordinary in this motion  
 ‘ [of the Cameleon’s eye] is, to see one of the eyes  
 ‘ move, whilst the other remains immoveable; and  
 ‘ the one to turn forward, at the same time that  
 ‘ the other looketh behind; the one to look up to  
 ‘ the sky, when the other is fixed on the ground.  
 ‘ And these motions to be so extreme, that they do  
 ‘ carry the Pupilla under the crest which makes the  
 ‘ eye-brow, and so far into the Canthi, or corners  
 ‘ of the eyes, that the sight can discern whatever  
 ‘ is done just behind it, and directly before, with-  
 ‘ out turning the head, which is fastened to the  
 ‘ shoulders.’ *Mem. for a nat. hist. in anatom. dissect.*  
*at Paris. Diff. of Camel, pag. 22.*

creatures their eyes are set out at a distance (*k*) from the head, to be circumvolved here and there; or one this, the other that way, at pleasure. And in creatures, whose eyes are without motion, as in divers insects; in this case, either they have more than two eyes, or their eyes are nearly two protuberant hemispheres, and each hemisphere often consisting of a prodigious number of other little segments of a sphere (*l*). By which means those creatures are so far from being deny'd any benefit of that noble and most necessary sense of sight, that they have probably more of it than other creatures, answerable to the rapidity of their flight, and brisk motion; and to their inquests after food, habitation, or repositories of generation, or such other necessity of the animal.

4. Another admirable provision in the eye, is its size; in some animals large, in some little. It would be endless here to enumerate particulars; as those of quadrupeds, birds, insects, and other terrestrial animals. And as for fishes, they will fall under another part of my survey.

I shall

(*k*) Snails send out their eyes at a distance, they being contained in their four horns, 'like atramentous spots, fitted to the ends of their horns, or rather to the ends of those black filaments or optic nerves, which are sheathed in their horns,' as Dr. Power wordeth it, *Obs.* 31. pag. 36. So the ingenious Dr. Lister, *Exercit. anat. oculi, & limac;*

(*l*) Vid. *l.* 8. c. 5. note (a).

I shall therefore only take notice of its size in one creature, the mole (*m*). As the habitation of that uncouth animal is wholly subterraneous, its lodging, its food, its exercises, nay,

(*m*) *Severinus* is of *Aristotle's*, *Pliny's*, and *Alb. Magnus's* opinion, that the Mole hath no sight; *G. Seger* denies any humour to be therein, but thinks they may probably see, because nature made nothing in vain. But *Borricbius* saith, their eyes have  
 'appendiculam nerveam in cerebrum euntem, cujus  
 'beneficio globuli illi [the little eyes] extra pellem  
 'facile poterant exferri, retrahique pro arbitrio----  
 'In illis oculorum globulis humor aqueus copiosè  
 'satis natabat; cæterorum non nisi tenue vestigium.' Blas. *Anat. anim.* c. 35.

'Et quoniam natura hoc vitæ genus ipsi destinavit, etiam perquam exiguos oculos----- dedit eo consilio, ut ii, pretiosissima corporis pars, a terræ pulvere nè affligerentur. Ii insuper pilis tecti, &c. Humores illis oculis insunt, & tunica nigra, uvea, se prodit. Ad hos tramite alio nervus venit.' Schneider in Blas. *ibid.*

Some time since I made divers accurate dissections of the eyes of Moles, with the help of microscopes, having a doubt whether what we take to be eyes were such or no. And upon a strict scrutiny I plainly could distinguish the vitreous and crystalline humours, yea, the *Ligamentum Ciliare*, and the atramentaceous *Mucus*. The *Pupil* I could manifestly discern to be round, and the *Cornea* copped, or conical: The eye is at a great distance from the brain, the optick nerve very slender and long, reaching from the eye through the intermediate flesh, and so passeth to the brain, along with the pair of nerves reaching

nay, even all its pastimes and pleasures, are in those subterraneous recesses and passages, which its own industry hath made for itself; so it is an admirable provision made in the size of the eye of that little creature, to answer all its occasions, and at the same time to prevent inconveniences. For as a little light will suffice an animal living always under ground; so the smallest eye will abundantly supply that occasion. And as a large protuberant eye, like that of other animals, would much annoy this creature in its principal business, of digging for its food and passage; so it is endowed with a very small one, commodiously seated in the head, and well fenced and guarded against the annoyances of the earth.

5. Another thing remarkable in this noble part of animals is, its Number; no less than two (*n*) in any instance that I know of; and in

reaching to the nose, which are much the largest that are in all the animal. These creatures, I imagine, have the faculty of withdrawing their eyes, if not quite into the head (as snails) yet more or less within the hair, as they have more or less occasion to use or guard their eyes.

*Galen* saith Moles have eyes, the crystalline and vitreous humours, encompassed with tunicks. *De usu part. l. 14. c. 6.* So accurate an anatomist was he for his time.

(*n*) *Pliny* tells us of a sort of Heron with but one eye, but it was only by hear-say, 'Inter aves ardeolarum genera, quos Leucos vocant, altero oculo carere tradunt.' *Nat. hist. l. 11. c. 37.* So the

in some animals more, as I have already hinted (o).

Now this is an admirable provision ; first, for the convenience of taking in the larger angle, or space : and in the next place, the animal is by this provision, in some measure, prepared for the misfortune of the loss of one of these noble, and necessary organs of its body.

But then besides all this, there is another thing considerable in this multiply number of the eye ; and that is, that the object seen is not multiplied as well as the organ, and appears but one, though seen with two or more eyes (p). A manifest sign of the infinite skill  
of

the king of the *Nigra* that hath but one eye, and that in his forehead, l. 6. c. 30. Which fables I take notice of more for the reader's diversion, than any truth in them.

(o) *Supra*, note (l).

(p) The most celebrated anatomists differ greatly about the reason why we see not double with two Eyes. This *Galen*, and others after him, generally thought to be from a coalition or decussation of the optick nerves, behind the *Oc Spbenoides*. But whether they decussate, coalesce, or only touch one another, they do not well agree. The *Bartholines* expressly assert, they are united, 'Non per simplicem contactum vel interfectionem in homine, sed totalem substantiæ confusionem.' *Anat. l. 3. c. 2.* And whereas *Vesalius*, and some others, had found some instances of their being disunited ; they say, 'Sed in plerisque ordinariè confunditur interior sub-  
stantia



of the contriver of this so noble a part, and of the exquisite art he employed in the formation thereof. But the design and skill of the infinite workman, will be best set forth by,

6. Sur-

‘stantia, ut accuratâ disquisitione deprehendi.’

But our learned Dr. *Gibson* (*Anat.* 4. 3. c. 10.) saith, ‘they are united by the closest conjunction, but not confusion of their fibres.

But others think the reason is not from any coalescence, contact, or crossing of the optick nerves, but from a sympathy between them. Thus *Monsieur Cartes* is of opinion, That the Fibrillæ, constituting the medullary part of those nerves, being spread in the Retina of each eye, have each of them corresponding parts in the brain; so that when any of those Fibrillæ are struck by any part of an image, the corresponding parts of the brain are thereby affected, and the soul thereby informed, &c. But see more hereafter under note (oo) from *Cartes* himself.

Somewhat like this is the notion of our judicious Dr. *Briggs*, who thinks the optick nerves of each eye consist of homologous Fibres, having their rise in the *Thalamus Nervorum Opticorum*, and thence continued to both the Retinæ, which are made of them: And farther, that those fibrillæ have the same parallelism, tension, &c. in both eyes; and consequently when an image is painted on the same corresponding sympathizing parts of each Retina, the same effects are produced, the same notice or information is carried to the Thalamus, and so imparted to the soul, or judging faculty. That there is such an *ὁμοιωμαθεια* between the Retinæ, &c. he makes very probable, from the ensuing of double vision upon the interruption of the parallelism of the eyes; as when one eye is depressed with the finger,

6. Surveying the parts and mechanism of this admirable organ the eye. And here indeed we cannot but stand amazed, when we view its admirable fabrick, and consider the prodigious exactness, and the exquisite skill employed in every part ministering to this noble and necessary sense. To pass by its arteries and veins, and such other parts common to the rest of the body, let us cast our eyes on its Muscles. These we shall find

finger, or their symphony interrupted by disease, drunkenness, &c. And lastly, that simple vision is not made in the former way, *viz.* by decussation or conjunction of the optick nerves, he proves, because those nerves are but in few subjects decussated, and in none conjoined otherwise than by a bare contact, which is particularly manifest in fishes; and in some instances it hath been found, that they have been separated without any double vision ensuing thereupon. *Vide Brig. Ophthalmog. cap. 11. § 5. and Nov. Vis. Theor. passim.*

What the opinion of our justly eminent Sir *Isaac Newton* is may be seen in his *Opticks*, Q. 15. 'Are not the species of objects seen with both eyes, united where the optick nerves meet before they come into the brain, the fibres on the right side of both nerves uniting there, &c. For the optick nerves of such animals as look the same way with both eyes (as of men, dogs, sheep, oxen, &c.) meet before they come into the brain; but the optick nerves of such animals as do not look the same way with both eyes (as of fishes, and of the Cameleon) do not meet, if I am rightly informed.' *Newt. Opt. Q. 15.*

find exactly and neatly placed for every motion of the eye. Let us view its Tunicks, and these we shall find so admirably seated, so well adapted, and of so firm a texture, as to fit every place, to answer every occasion, and to be proof against all common inconveniences and annoyances. Let us examine its three Humours, and these we shall find all of exquisite clearness and transparency, for an easy admission of the rays ; well placed for the refracting of them, and formed (particularly the crystalline humour) by the nicest laws of opticks, to collect the wandring rays into a point. And to name no more, let us look into its darkned cell, where those curious humours lie, and into which the glories of the heavens and the earth are brought, and exquisitely pictured ; and this cell we shall find, without, well prepared by means of its texture, aperture, and colour, to fence off all the useless or noxious rays ; and within as well coated with a dark tegument, that it may not reflect, dissipate, or any way confuse or disturb the beneficial rays (g).

But

(g) — Nigra est [*Uvea*] ut radios (ab oculi fundo ad anteriorem ejus partem reflexos) obumbret ; nè hi (ut ait clar. Cartesius) ad oculi fundum re-torti ibidem confusam visionem efficerent. Alia forsan ratio hujus nigredinis statuatur, quòd radii in visione superflui, qui ab objectis lateralibus proveniunt, hoc ritu absorbeantur. Ita enim è loco obscuro interdum objecta optimè intuemur, quia radii tunc temporis circumfuso lumine non diluuntur. Brigg's *Ophtbal.* ch. 3. § 5.

But to descend to particulars, although it would be a great demonstration of the glory of God, yet would take up too much time, and hath been in some measure done by others that have written of God's works. Passing over therefore what they have observed, I shall under each principal part take a transient notice of some things they have omitted, or but slightly spoken of.

And my first remark shall be concerning the muscles of the eye, and their equilibration. Nothing can be more manifestly an act of contrivance and design, than the muscles of the eye, admirably adapted to move it any, and every way; upwards, downwards, to this side or that, or howsoever we please, or there is occasion for, so as to always keep that parallelism of the eye, which is necessary to true vision. For performance of which service, the form, the position, and the due strength of each muscle is admirable. And here I might instance the peculiar and artificial structure of the Trochlearis, and the augmentation of its power by the Trochlea (*r*); the magnitude and

(*r*) 'Admirandum Dei artificium ex diversorum animalium comparatione indies evadit manifestius. Mirantur omnes trochlearem in oculis hominum & quadrupedum, & quidem jure: sed admirationem omnem superat, quod sine trochleâ oculum movens in avibus novum genus trochleæ longè artificiosius nictitandi membranæ dederit.' Blas.

*Anat. animal. p. 2. c. 4. ex Stenon.*

N 2

[Musculum]

strength of the Attollent Muscle, somewhat exceeding that of its antagonist; the peculiar muscle, called the Seventh, or Suspensory Muscle (s), given to brutes, by reason of the prone posture of their bodies, and frequent occasions to hang down their heads: And I might speak also of the peculiar origin and insertion

‘ [*Musculum Trochlearem*] per intermediam trochleam traductum, nunquam intueor, quin admirandus mecum, ‘Ο Θεός, exclamem, οὐ μόνον αὐτὴ γεωμετρική, ἀλλὰ καὶ αὐτὴ μηχαναὶ ται. I. C. Sturmii *Exercit. acad. 9. de vis. org. & rat. c. 3. § 4. p. 446.*

(s) ‘ Observare est quod Quadrupedes, qui oculos in terram pronos, ac pendulos gerunt, musculum peculiarem habent, quo oculi globus suspenditur---- Hoc musculo, bos, equus, ovis, lepus, porcus, &c. præditi sunt: hoc etiam canis instruitur, sed alio modo conformatum habet.’ Willis *de An. brut. p. 1. c. 15.*

Of this opinion also was *Bartboline*, *Anat. l. 3. c. 8.* and divers other eminent anatomists.

But Dr. *Briggs* is of opinion, that the Adnata and the other muscles sufficiently answer all those ends ascribed to that muscle by former anatomists, and thinks ‘ Probabilius itaque esse hunc musculum ‘ nervi optici actionem (per vices) confirmare, nè ‘ à prono brutorum incessu & copioso affluxu humorum debilitetur.’ *Ophthal. c. 2. § 2.*

The Musculus Suspensorius being in the Porpoise, as well as brutes, Dr. *Tyson* thinks the use of it is not to suspend the bulk of the eye, but rather by its equal contraction of the Sclerotis, to render the ball of the eye more or less spherical, and so fitter for vision. *Tyson’s Anat. of the Porpoise, p. 39.*



feration of the lower Oblique Muscle (*r*), which is very notable, and many other things relating to these parts; but it would be tedious to descend too much to those admirable particulars. And therefore to close up these remarks, All I shall farther take notice of, shall be only the exquisite Equilibration of all these Opposite and Antagonist Muscles, affected partly by the equality of the strength; which is the case of the Adducent and Abducent Muscles; partly by their peculiar origin, or the addition of the Trochlea, which is the case of the Oblique Muscles (*u*); and partly by the natural

(*r*) ‘Musculus obliquus inferior oritur à peculiari quodam foramine in latere orbitæ ocularis facto (contra quàm in cæteris, &c.) quo fit ut ex unâ parte à musculo trochleari, ex alterâ verò ab hujus musculi commodissimâ positione, oculus in æquilibrio quodam constitutus, irretorto obtutu versus objecta feratur, nec plus justo accedat versus internum externumve canthum; quæ quidem libratio omnino nulla fuisset, absque hujus musculi peculiari originatione (cujus ratio omnes hucusque anatomicos latuit.)’ And so this curious anatomist goes on to shew farther the stupendous artifice of the great Creator in this position of the Oblique Muscles. Briggs’s *Nova vis. theor.* p. 11. *mco libro.*

(*u*) Besides those particular motions which the eye receives from the Oblique Muscles, and I may add its liberation also in some measure, some anatomists ascribe another no less considerable use to them; namely, to lengthen and shorten the eye



ral posture of the body, and the eye, which is the case of the Attollent and Depriment Muscles. By this so curious and exact a libration, not only unseemly contortions, and incommodious vagations of the eye are prevented, but also it is able with great readiness and exactness to apply itself to every object.

As to the Tunicks of the eye, many things might be taken notice of, the prodigious fineness of the Arachnoides, the acute sense of the Retina, the delicate transparency of the Cornea (*w*), and the firm and strong texture of that and the Sclerotica too; and each of them, in these and every other respect, in the most accurate manner adapted to the place in which it is, and the business it is there to perform. But for a sample, I shall only take notice of that

(by squeezing and compressing it) to make it correspond to the distance of all objects, according as they are nigh or far off. Thus the ingenious Dr. Keil: 'The aqueous humour being the thinnest and most liquid, easily changeth its figure, when either the Ligamentum Ciliare contracts, or both the Oblique Muscles squeeze the middle of the ball of the eye, to render it oblong when objects are too near us.' Keil's *Anat. chap. 4. §. 4.* See note (*y*).

(*w*) 'Quis verò opifex præter naturam, quâ nihil potest esse callidius, tantam solertiam persequi potuisset in sensibus? quâ primum oculos membranis tenuissimis vestivit, & sepiit: quas primum perlucidas fecit, & per eas cerni posset: firmas autem, ut continerentur.' Cic. *de nat. deor. l. 2. c. 57.*

that part of the Uvea which makes the Pupil It hath been observed by others, particularly by our honourable Founder (x), That as we are forced to use various apertures to our optick glasses, so nature hath made a far more compleat provision in the eyes of animals, to shut out too much, and to admit sufficient light, by the dilation and contraction of the Pupil (y). But it deserveth our especial remark, that these pupils are in divers animals of divers forms, according to their peculiar occasions. In some (particularly in man) it is round; that being the most proper figure for the position of our eyes, and the use we make of them both by day and night. In some other animals it is of a longish form; in some transverse (z), with its aperture large, which

(x) Boyle of *Final Causes*.

(y) It is easy to be observed, that the Pupil openeth in dark places; as also when we look at far distant objects, but contracts by an increase of light, and when the objects are nigh. This motion of the Pupil some say, is effected by the circular and strait fibres of the Uvea, and some attribute it to the Ligamentum Ciliare. Yet I have no great doubt but that they both concur in that action, and that the Ligamentum Ciliare doth, at the same time the pupil opens and shuts, dilate or compress the Crystalline, and bring it nigher unto, or carry it farther off the Retina. For the structure of the Ligamentum Ciliare, and its two sorts of fibres, drawn by the help of a microscope, I shall refer to Mr. Cowper's *Anat. T. 11.*

(z) 'In bove, caprâ, equo, ove, & quibusdam aliis elliptica est [*Pupilla*] ut eo magis in hisce

which is an admirable provision for such creatures to see the better laterally, and thereby avoid inconveniencies, as well as help them to gather their food on the ground, both by day and night. In other animals the fissure of the pupil is erect (*aa*), and also capable of opening wide, and shutting up close. The latter of which serves to exclude the brighter light of the day, and the former to take in the more faint rays of the night, thereby enabling those nocturnal animals (in whom generally this erect form of the pupil is) to catch their prey with

‘ forsan animalibus, quæ prono incessu victum in  
‘ agris quæritant, radios laterales ad mala & in-  
‘ commoda utrinque devitanda admittat.’ Briggs’s  
*Opthbal. c. 7. § 6.*

‘ Homini erecto, aliisque, &c. caput erigere, &  
‘ quaquaversus circumspicere solitis, plurima simul  
‘ objecta, tum suprà, tum infrà, tum è latere utro-  
‘ que----visu excipiuntur; quapropter oculi pu-  
‘ pillæ rotunda esse debet.----Attamen bovi, &c.  
‘ caput ferè semper pronum----gerentibus, tantum-  
‘ que coràm, & paulo à latere obversantur, intuitu  
‘ opus est: quapropter pupilla----oblonga est, &c.’  
*Willis de Anim. brut. p. 1. c. 15.*

(*aa*) Thus Cats (their pupils being erect, and the shutting their eye-lids transverse thereunto) can so close their pupil, as to admit of, as it were, only one single ray of light; and by throwing all open, they can take in all the faintest rays. Which is an incomparable provision for these animals, that have occasion to watch and way-lay their prey both by day and night.

with the greater facility in the dark (*bb*), to see upwards and downwards, to climb, &c. Thus much for the Tunicks, The

(*bb*) There is besides this large opening of the pupil, in some nocturnal animals, another admirable provision, enabling them to catch their prey in the dark; and that is, a radiation of the eyes: Of which Dr. *Willis* thus: 'Hujus usus est oculi pupillam, quasi jubare insito, illuminare, ut res noctu, & in tenebris positas conspiciere valeat; quare in fele plurimum illustris est: at homini, avibus & piscibus deest.' This illumination he speaks of, is from the Tapetum, in the bottom of the eye, or the shining of the Retina, round the optick nerve.

Besides which, he saith, the Iris hath a faculty also, in some, of darting out rays of light, so as to enable them to see in the dark: of which he tells this story; 'Novi quendam cerebro calidiori præditum, qui post uberiores vini generosi potum in nocte atratâ, sive tenebris profundis, li teras distincte legere potuit. Cujus ratio videtur esse, quod spiritus animales velut accensi, adeoque ab hac Iride irradiantes, jubare insito medium illuminabant.' *Willis ibid.*

Such another thing, *Pliny* tells us, was reported of *Tiberius Cæsar*; 'Ferunt Tib. Cæs. nec alii genitorum mortalium, fuisse naturam, ut expergefactus noctu paulisper, haud alio modo quam luce clarâ, contueretur omnia.' *Nat. hist. l. 11. c. 37.*

So Dr. *Briggs*; 'Virum sanè calidæ indolis novi in Comitatu Bedfordiensi degentem, qui oculis felineis---donatus est: adeò ut epistolam-----mire admodum in loco obscuro (ubi eadem mihi vix apparuit) perlegit. Hujus verò oculi (nisi quod pupillas insigniores obtinuerent) ab aliorum formatione neutiquam discrepabant.' *Ophtbal. c. 5. § 12.*

The next thing I shall take notice of, will relate to the Humours of the eye, and that only concerning the mechanism of the Crystalline Humour; not its incomparable transparency; nor its exact lenticular form; nor its curious araneous membrane (cc), that constringeth

(cc) The Tunica Aranea is taken notice of by Friar Bacon, who calls it, Tela Aranea, and saith, 'in hâc continetur----- glaciale vel Crystallinum. Rog. Bacon's *Perspect. distinct.* 2. c. 3. The wrinkling of this, and the Cornea (as the skin is of old persons) he thinks is the cause of the obscurity of the sight in such persons. Bacon, *ibid. par.* II. cap. 2. But this Tunick some deny, and others allow of, Dr. A. M. of Trinity College, Dublin (in his *Relat. of Anat. obs.* in the eyes of animals, in a letter to Mr. Boyle, an. 1682, annexed to his *Anat. account of the Elephant burnt in Dublin, p. 57.*) affirms the Tunica Aranea, and saith, 'I have often seen it before it was exposed to the air one minute, notwithstanding what Dr. Briggs saith to the contrary, &c.' But Dr. Briggs's opinion is, 'Humor Crystallinus, nisi aeri diutius expositus, vel leniter coctus (instar lactis) cuticulam non acquirit: quæ vero improprie Tunica Aranea dicitur, cum sit tantum adventitia, ut in oculo Bovis recens execto appareat.' Briggs's *Ophtbalm.* c. 3.

The Crystalline Humour being of a double substance, outwardly like a jelly, towards the center as consistent as hard suet, upon occasion whereof its figure may be varied; which variation may be made by the Ligamentum Ciliare; Dr. Grew doth, upon these accounts, not doubt to ascribe to the Ligamentum Ciliare, a power of making the Crystalline  
more

stringeth and dilateth it, and so varieth its Focus (if any such variation there be, as some affirm

more convex, as well as of moving it to or from the Retina. See *Grew's Cosmolog. Sacr. l. 1. c. 4.* Now it is certain by the laws of opticks, that somewhat of this is absolutely necessary to distinct vision, inasmuch as the rays proceeding from nigh objects do more diverge, and those from distant objects less: which requires either that the Crystalline Humour should be made more convex, or more flat; or else an elongation, or shortening of the eye, or of the distance between the Crystalline Humour and the Retina.

But altho' Dr. *Briggs* (so good a judge) denies the Tunica Crystallina, contrary to the opinion of most former anatomists; yet there is great reason to conclude he was in a mistake, in my opinion, from the observations of the *French Anatomists*, of the Crystalline of the eye of the Gemp or Chamois, who say, 'The Membrana Arachnoïdes was very thick, and hard, so that it was easily separated from the Crystallinus.' p. 145.

The same anatomists also favour the surmise of Dr. *Grew*. This [contraction of the fibres of the Ligamentum Ciliare on one side, and dilation on the other] 'would make us think that these fibres of the Ligamentum Ciliare are capable of contraction, and voluntary dilatation, like that of the fibres of the muscles; and that this action may augment, or diminish the convexity of the Crystallinus, according as the need which the distance of the objects may make it to have on the eye, to see more clearly and distinctly.' *Anat. Descript. of a Bear. p. 49.*

Since



affirm with great probability) nor lastly, its admirable approach to or from the Retina, by the help of the Ciliar Ligament (*dd*), according

Since my penning the foregoing notes, having as critically as I could, dissected many eyes of birds, beasts, and fishes, I manifestly found the Membrana Arachnoïdes, and will undertake to shew it any one with great ease and certainty. It is indeed so transparent, as not to be seen distinct from the Crystalline. But if the Cornea and Uvea be taken off before, or the vitreous Humour behind it, and the outside of the Crystalline be gently cut, the Arachnoïdes may be seen to open, and the Crystalline will easily leap out, and part from the Ligamentum Ciliare; which otherwise it would not do: For it is by the Arachnoïdes braced to the Ligamentum Ciliare. This membrane or tunick, in the ox, is so substantial and strong, tho' thin, that it yields to, or sinks under the sharpest lancet, and requires (for so thin and weak a membrane in appearance,) a strong pressure to pierce it.

(*dd*) As birds and fishes are in divers things conformable, so in some sort they are in their eye, to enable it to correspond to all the convergences, and divergences of the rays, which the variation of each of the mediums may produce. For this service the Tunica Choroides, in fishes, hath a musculous substance at the bottom of it; lying round the optick nerve, at a small distance from it; by which means I imagine they are able to contract, and dilate the Choroides, thereby to lengthen and shorten the eye: For the helping in which service, I imagine it is that the Choroides, and Sclerotica are in a great measure parted, that the Choroides may have

ding as objects are far off or near, because these things are what are usually taken notice of ;  
but

have the greater liberty of acting upon the humours within.

But in birds, I have myself found, that although the Choroides be parted from the Sclerotica, yet the Choroides hath no muscle, but instead thereof, a curious pectinated work, seated on the optick nerve, represented in *fig. II.* In which *c. a. c. b. d.* represents the Choroides and Sclerotica ; *a. b.* the part of the Optick Nerve that is within the eye ; *v. v. v.* the vitreous Humour ; *a. f. g. b.* the Pecten ; *b. i.* the Crystalline. For the reception of this Pecten, the Optick Nerve comes farther within the eye, than in other creatures. The structure of this Pecten is very like that of the Ligamentum Ciliare ; and in the eye of a Magpye, and some others, I could perceive it to be musculous towards the bottom. This Pecten is so firmly fixed unto, or embodied in the vitreous humour, that the vitreous humour hangs firmly to it, and is not so easily parted from it. By which means all the motions of the Pecten are easily communicated to the vitreous humour, and indeed to all contained in the Choroides. And forasmuch as the Crystalline is connected to the vitreous humour, therefore also the alterations in the vitreous humour affect also the Crystalline ; and the Crystalline hereby brought nearer unto, or farther from the Retina, as occasion is.

Besides all which observables in the Choroides, and inner eye, I have also found this farther remarkable in the Sclerotica, and outer-part of the eye of birds ; *viz.* That the fore-part of the Sclerotica is horny and hard, the middle-part thin and

but that which I shall observe is, the prodigious art and finery of its constituent parts, it being, according to some late nice microscopical

flexible, and braces intervene between the fore and hind-part, running between the Choroides and Sclerotica; by which means the Cornea, and back-part of the eye are brought to the same conformity that the rest of the eye hath.

The great end and design of this singular and curious apparatus in the eyes, both of birds and fishes, I take to be, 1. To enable those creatures to see at all distances, far off or nigh; which (especially in the waters) requireth a different conformation of the eye. In birds also, this is of great use, to enable them to see their food at their bill's end, or to reach the utmost distances their high flights enable them to view; as to see over great tracts of sea or land, whither they have occasion to fly; or to see their food or prey, even small fishes in the waters, and birds, worms, &c. on the earth, when they sit upon trees, high rocks, or are hovering high in the air. 2. To enable those animals to adapt their eye to all the various refractions of their medium. Even the air itself varies the refractions, according as it is rarer or denser, more or less compressed; as is manifest from the learned and ingenious Mr. Lowthorp's experiment in *Philos. Transact.* N<sup>o</sup> 257. and some other experiments since of the before-commended Mr. Hawksbee, both in natural, rarefied, and compressed air; in each of which, the refractions constantly varied in exact proportion to the rarity or density of the air. *Vide Hawksbee's Exp.* p. 175, &c.

Besides this conformity in general, between the eyes of birds and fishes, *Du Hamel* tells us of a singular

pical observations (*ee*), composed of divers thin scales, and these made up of one single minutest thread or fibre, wound round and round, so as not to cross one another in any one place, and

gular conformity in the Cormorant's eye, and that is, that the Crystalline is globous, as in fishes, to enable it to see and pursue its prey under water : which *J. Faber*, in *Mr. Willoughby*, saith, they do 'with wonderful swiftness, and for a long time.' *Will. Ornitbol.* p. 329.

(*ee*) The Crystalline Humour, when dried, doth manifestly enough appear to be made up of many very thin spherical Laminæ, or scales lying upon one another. *Mr. Leuwenboeck* reckons there may be two thousand of them in one Crystalline, from the outermost to the centre. Every one of these scales, he saith, he had discovered to be made up of one single fibre, or finest thread, wound, in a most stupendous manner, this way, and that way, so as to run several courses, and meet in as many centres, and yet not to interfere, or cross one another, in any one place. In Oxen, Sheep, Hogs, Dogs and Cats, the thread spreads into three several courses, and makes as many centres : In Whales five ; but in Hares and Rabbits only two. In the whole surface of an Ox's Crystalline, he reckons there are more than twelve thousand fibres juxtaposited. For the right and clear understanding of the manner of which admirable piece of mechanism, I shall refer to his cuts and descriptions in *Philos. Transf.* N<sup>o</sup> 165 and 193. The truth hereof I have heard some ingenious men question ; but it is what I myself have seen, and can shew to any body, with the help of a good microscope.

and yet to meet, some in two, and some in more different centres ; a web not to be woven, an Optick Lens, not to be wrought by any art less than infinite wisdom.

Lastly, To conclude the parts of this admirable organ, I shall only make one remark more, and that is about its Nerves. And here, among others, the admirable make of the Optick Nerves might deserve to be taken notice of in the first place, their Medullary part (*ff*) terminating in the brain itself, the teguments propagated from the Meninges, and terminating in the coats of the eye, and their commodious insertions into the ball of the eye, in some directly opposite to the pupil of the eye, in others obliquely towards one side (*gg*). But  
most

(*ff*) S. Malpighi observed the middle of the Optick Nerve of the Sword-fish to be nothing else but a large membrane, folded according to its length in many doubles, almost like a fan, and invested by the Dura Mater ; whereas in land animals it is a bundle of fibres. *Vide Philos. Trans. N° 27.*

(*gg*) ‘ Certissimum est, quodd in omnibus oculis humanis (quos saltem mihi dissecare contigit) nervus opticus pupillæ è diametro opponitur, &c.’ Briggs: *Optical. cap. 3. § 15.* Ita Willis de *Anim. brut. p. 1. c. 15.*

‘ Nervi optici in nobis, item in cane, felle (& in cæteris forsan animalibus calidis) ad fundum oculi delati pupillæ regioni prospiciunt, dum interim in aliis quadrupedibus, uti etiam in piscibus & volucribus, obliquè semper Tunicæ Sclerotidi inseruntur.’ Willis, *ib. cap. 7. § 11.*

most of these things have been treated of, and the convenience hereof set forth, by others that have written of God's works. I shall therefore take notice only of one wise provision the Creator hath made about the motion of the eye, by uniting it into one, the third pair of nerves, called the Motory Nerve (*bb*), each of which sending its branches into each muscle of each eye, would cause a distortion in the eyes; but being united into one, near their insertion into the brain, do thereby cause both eyes to have the same motion; so that when one eye is moved this way and that way, to this and that object, the other eye is turned the same way also.

Thus from this transient and slight view (I may call it) of the parts of the eye, it appears what an admirable artist was the contriver thereof. And now in the

Seventh and last place, let us consider what provision this admirable artist hath made for the Guard and Security of this so well form'd organ (*ii*). And here we shall find

(*bb*) ' This pair is united at its rise; whence is commonly drawn a reason why one eye being mov'd towards an object, the other is directed also to the same.' Gibson's *Anat.* book iii. cap. 11. So *Bartboline Anat.* libellus 3. cap. 2.

(*ii*) Among all the other security the eye hath, we may reckon the reparation of the Aqueous Humour; by which means the eye when wounded, and that in all appearance very dangerously too, doth often recover its sight: Of which *Bern. Ver-*



find the guards equivalent to the use and excellency of the part. The whole organ fortified and fenced with strong, compact bones, lodged in a strong, well-made socket, and

*nafeba* gives divers examples ancient and modern. One is from *Galen*, of a boy so wounded, that the Cornea fell, and became flaccid, but yet recovered his sight. Other such like instances also he gives from *Realdus Columbus*, *Rhodius*, and *Tulpius*; and one that he cured himself in these words; ‘Ego in nobilissimi viri filiola similem casum observavi: hæc dum levibus de causis cum fratre altercaret, iste iracundiâ percitus cultellum Scriptorium apprehendit, & sororis oculo vulnus infligit, inde humor aqueus effluxit. Vocatus præsentem chirurgum jussi sequens collyrium anodynum & efficans tepidè sæpiùs admovere. *Recip. aq. Plantag. drach. iv. Rosar. Sanicul. Euphras. ana. Trochisc. alb. Rhascum Opio scrup. ij. Tutia pp. scrup. j. Croci orient. scrup. sem. scrup. M.* Hoc Collyrium inflammationem compescuit, vulnus sicavit & sanavit. Hinc post aliquot menses Humor aqueus succrevit. Nam visus, sed debilior, cum summo parentum gaudio redivit.’ *B. Verzascha Observ. medicæ. observ. 14.*

Another cure of this kind was experimented by *Dr. Daniel Major*, upon a goose, *ann. 1670.* the Aqueous Humour of both whose eyes they let out, so that the eyes fell, and the goose became quite blind: But without the use of any medicine, in about two days time, nature repaired the watery humour again, the eyes returned to their former turgency, and the goose was in a week after produced seeing before twenty-eight or thirty spectators. *Epheem. Germ. T. 1. Add. ad obs. 117.*

and the eye itself guarded with a nice made cover (kk). Its humours, and its inward tunicks,

From the same cause, I doubt not, it was that the eye of a gentleman's daughter, and those of a cock, when wounded, so that the Cornea sunk, were restored by a *Lithuanian* Chymist, that passed for a conjurer, by the use of a liquor found in *May*, in the vesiculæ of Elm. Of which see Mr. *Ray's Catal. Cantab.* in *Ulmus*, from *Henr. ab Heers*.

(kk) 'Palpebræ, quæ sunt tegumenta oculorum mollissimæ tactu, nè læderent aciem, aptissimæ factæ, & ad claudendas Pupillas, nè quid incideret, & ad aperiendas; idque providit, ut identidem fieri posset cum maximâ celeritate. Munitæque sunt Palpebræ tanquàm vallo pilorum: quibus & apertis oculis, si quid incideret, repelleretur, & somno conniventibus, cùm oculis ad cernendum non egeremus, ut qui, tanquàm involuti, quiescerent. Latent præterea utiliter, & excelsis undique partibus sepiuntur. Primum enim superiora superciliis obducta sudorem à capite, & fronte defluentem repellunt. Genæ deinde ab inferiore parte tutantur subjectæ, leviterque eminentes.' *Cicer. de nat. deor. l. 1. c. 57.*

*Tully*, in the person of a Stoick, having so well accounted for the use of the eye-lids, I shall for a further manifestation of the Creator's contrivance and structure of them, take notice of two or three things: 1. They consist of a thin and flexible, but strong skin, by which means they the better wipe, clean, and guard the Cornea. 2. Their edges are fortified with a soft cartilage, by which means they are not only enabled the better to do their office, but also to close and shut the better. 3. Out of these cartilages grows a palisade of stiff hairs, of great

nicks, are indeed tender, proportionate to their tender, curious uses ; but the coats with-

great use to warn the eye of the invasion of dangers, to keep off motes, and to shut out too excessive light, &c. and at the same time to admit of (through their intervals) a sufficient passage for objects to approach the eye. And it is remarkable, that these hairs grow but to a certain commodious length, and need no cutting, as many other hairs of the body do : Also, that their points stand out of the way, and in the upper-lid bend upwards, as they do downwards in the lower-lid, whereby they are well adapted to their use. From which last observables, we may learn how critical and nice the great author of nature hath been, in even the least and most trivial conveniences belonging to animal bodies ; for which reason I have added it to *Tully's* remarks. And more might have been added too, as particularly concerning the curious structure and lodgment of the Right Muscle, which opens the eye-lids ; and the Orbicularis, or Circular one, that shuts them ; the nice Apparatus of glands that keep the eye moist, and serve for tears ; together with the reason why man alone, who is a social animal, doth exhibit his social affections by such outward tokens as tears ; the nerves also, and other organs acting in this ministry. I might also speak of the passages for discharging the superfluous moisture of the eyes through the nostrils, and much more of the like kind. But it would take up too much room in these notes ; and therefore it shall suffice to give only such hints as may create a suspicion of a noble oeconomy and contrivance in this (I had almost said) least considerable part of the eye. But for particulars I shall refer to the anatomists ; and

without, are context and callous, firm and strong: And in some animals, particularly birds,

and for some of these things particularly to Dr. *Willis's Cereb. Anat.* and *de Anim. brut.* and Mr. *Cowper's* elegant cuts in the 11th Tab. of his Anatomy.

To the eye-lids we may add another guard afforded the eyes of most quadrupeds, birds, and fishes, by the Nictitating Membrane, which Dr. *Willis* gives this account of, 'Plurimis [*animalibus*] quibus musculus suspensorius adest (*which limitation be needed not to have added*) etiam alter membranofus conceditur, qui juxta interiorem oculi canthum situs, quando elevatur, oculi globum ferè totum obtegit. Hujus usus esse videtur, ut cum bestiae inter gramina, &c. capita sua propter victum capessendum demergunt, hic musculus oculi pupillam, nè à stipularum incurfu feriatur, oculi muniatque.' *De anim. brut. p. 1. c. 15.*

This membrane man hath not, he having little occasion to thrust his head into such places of annoyance, as beasts, and other animals; or if he hath, he can defend his eyes with his hands. But birds (who frequent trees and bushes) and quadrupeds (hedges, and long grass) and who have no part ready, like the hand, to fence off annoyances: these, I say, have this incomparable provision made for the safety of their eyes. And for fishes, as they are destitute of eye-lids, because there is no occasion for a defensive against dust and motes, offensive to the eyes of land-animals, nor to moisten and wipe the eyes, as the eye-lids do, so the Nictitating Membrane is an abundant provision for all their occasions, without the addition of the eye-lids.

And now, if we reflect, are these the works of any thing but a wise and indulgent agent?

birds (*ll*), some part of those tunicles have the nature and hardness of bone or horn.

But for creatures, whose eyes, like the rest of their body, are tender, and without the guard of bones; their nature hath provided for this necessary and tender sense, a wonderful kind of guard, by endowing the creature with a faculty of withdrawing its eyes into its head (*mm*), and lodging them in the same safety with the body.

Thus have I survey'd this first sense of animals, I may say in a cursory, not accurate, strict manner, considering the prodigious workmanship thereof; but so, as abundantly to demonstrate it to be the contrivance, the work of no less a being than the infinite, wise; potent, and indulgent Creator (*nn*). For none less could compose so admirable an organ,

(*ll*) Although the hardness and firmness of the Adnata, or Sclerotica, in birds, is a good guard to their eyes, yet I do not think it is made thus so much for a defence, as to minister to the lengthning and shortning the eye, mentioned before in note (*cc*).

(*mm*) 'Cochleis oculorum vicem Cornicula bina prætentu implent.' Plin. *Nat. hist.* l. II. c. 37. See more of the eyes of Snails before in note (*k*); and in note (*l*) I said that I suspected Moles also might thrust out, or withdraw their eyes more or less within the hair or skin.

(*nn*) The diligent *Sturmius* was fully persuaded there could not be any speculative atheism in any one that should well survey the eye. 'Nobis (saith he)

' fuit

gan, so adapt all its parts, so adjust it to all occasions, so nicely provide for every use, and for every emergency : In a word, none less than God could, I say, thus contrive, order, and provide an organ, as magnificent and curious as the sense is useful ; a sense without which, as all the animal world would be in perpetual darkness, so it would labour under perpetual inconveniencies, be exposed to perpetual harms, and suffer perpetual wants and distresses. But now by this admirable sense, the great God, who hath placed us in this world, hath as well provided for our comfortable residence in it ; enabled us to see and chuse wholesome, yea, delicate food ; to provide ourselves useful, yea, gaudy cloathing, and commodious places of habitation and retreat. We can now dispatch our affairs with alacrity and pleasure, go here and there as our occasion calls us. We can, if need be, ransack the whole globe, penetrate into the bowels of the earth, descend to the bottom of the deep, travel to the farthest regions of this world, to acquire wealth, to increase our knowledge, or even only to please our eye and fancy. We can now look about us, discern

and

‘ fuit persuasissimum, atheismum, quem vocant speculativum, h. e. obfirmatam de deitate in universo nullā persuasionem, habere locum aut inveniri non posse in eo homine, qui vel unius corporis organici, & speciatim oculi fabricam attentō animo aspexerit.’ Sturm. *Exerc. acad. 9. de Vis. organ. & rat. in epologo.*



and shun the precipices and dangers which every where enclose us, and would destroy us. And those glorious objects which fill the heavens and the earth, those admirable works of God which every where surround us, and which would be as nothing to us, without being seen, do by means of this noble sense present their glories to us (so), and fill us with admiration and pleasure. But I need not expatiate in the usefulness and praises of this sense, which we receive the benefit of every moment, and the want, or any defect of which, we lament among our greatest misfortunes.

Leaving

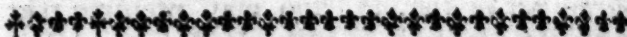
(so) The glorious landships, and other objects that present themselves to the eye, are manifestly painted on the Retina, and that not erect, but inverted as the laws of opticks require; and is manifest to the eye from Monsieur *Cartes*'s experiment, of laying bare the vitreous humour on the back-part of the eye, and clapping over it a bit of white paper, or the skin of an egg; and then placing the fore-part of the eye to the hole of the window of a darkned room. By which means we have a pretty landskip of the objects abroad invertedly painted on the paper, on the back of the eye. But now the question is, how in this case the eye comes to see the objects erect; Monsieur *Cartes*'s answer is,

‘ Notitia illius ex nullâ imagine pendet, nec ex ullâ  
 ‘ actione ab objectis veniente, sed ex solo situ exi-  
 ‘ guarum partium cerebri, è quibus nervi expullu-  
 ‘ lant.---- E. g. cogitandum in oculo-----situm ca-  
 ‘ pillamenti nervi optici-----respondere & alium  
 ‘ quendam partis cerebri-----qui facit ut anima sin-  
 ‘ gula loca cognoscat, quæ jacent in rectâ, aut quasi  
 ‘ rectâ

Leaving then this sense, I shall proceed to the other four, but more briefly treat of them, by reason we have so ample a sample of the divine art in the last, and may presume that the same is exerted in all as well as one. For  
a

‘ rectâ lineâ ; ut ita mirari non debeamus corpora  
 ‘ in naturali situ videri, quamvis imago in oculo  
 ‘ delineata contrarium habeat.’ *Dioptr. c. 6.* But  
 our most ingenious Mr. *Molyneux* answereth thus ;  
 ‘ The eye is only the organ or instrument, it is the  
 ‘ soul that sees by means of the eye. To enquire  
 ‘ then how the soul perceives the object erect, by  
 ‘ an inverted image, is to enquire into the soul’s  
 ‘ faculties----- But erect and inverted are only  
 ‘ terms of relation to up and down ; or farther  
 ‘ from, or nigher to the centre of the earth, in  
 ‘ parts of the same thing.-----But the eye, or vi-  
 ‘ sive faculty takes no notice of the internal posture  
 ‘ of its own parts, but useth them as an instrument  
 ‘ only, contrived by nature for the exercise of such  
 ‘ a faculty.----Let us imagine, that the eye (on its  
 ‘ lower part) receives an impulse [ by a ray from  
 ‘ the upper part of the object ] must not the visive  
 ‘ faculty be necessarily directed hereby to consider  
 ‘ this stroke, as coming from the top rather than  
 ‘ the bottom [ of the object ] and consequently be  
 ‘ directed to conclude it the representation of the  
 ‘ top ? Hereof we may be satisfied, by supposing a  
 ‘ man standing on his head. For here, tho’ the  
 ‘ upper parts of objects are painted on the upper  
 ‘ parts of the eye, yet the objects are judged to be  
 ‘ erect. What is said of erect and reverse, may be  
 ‘ understood of sinister and dexter.’ *Molyneux’s*  
*Dioptr. nov. part I. prop. 28.*

a demonstration of which, let us in the next place carry our scrutiny to the sense of Hearing.



### C H A P. III.

#### *Of the Sense of Hearing.*

**C**ONCERNING the sense of Hearing, I shall take notice of two things, the organ, the Ear, and its object, Sound.

I. For the organ, the Ear; I shall pass by its convenient number of being double, which (as in the last sense) serves for the commodious hearing every way round us; as also a wise provision for the utter loss or injury (a) of one of the ears. But I shall a little insist upon its situation, and its admirable fabrick and parts.

I. It

(a) I presume it will not be ungrateful to take notice here of the admirable, as well as useful sagacity of some deaf persons, that have learn'd to supply their want of hearing by understanding what is said by the motion of the lips. My very ingenious friend Mr. *Waller*, R. S. Secr. gives this account: ' There live now, and have from their birth, in our town, a man and his sister, each about fifty years old, neither of which have the least sense of hearing,-----yet both of these know, by the motion of the lips only, whatever is said to them, and will answer pertinently to the question proposed to them,----- The mother told me they could hear very well, and speak when they were

1. It is situated in the most convenient part of the body (like as I said the eye is) in a part near

‘ were children, but both lost that sense afterwards, which makes them retain their speech ; though that, to persons not used to them, is a little uncouth and odd, but intelligible enough.’ *Philosoph. Transact. N<sup>o</sup>. 312.*

Such another Instance is that of Mr. Goddy, minister of St. *Gervais* in *Geneva*, his daughter. ‘ She is now about sixteen years old : Her nurse had an extraordinary thickness of hearing ; at a year old, the child spake all those little words that children begin to speak at that age.-----At two years old, they perceived she had lost her hearing, and was so deaf, that ever since, though she hears great noises, yet she hears nothing that one can speak to her.----- But by observing the motions of the mouth and lips of others, she hath acquired so many words, that out of these she hath formed a sort of jargon, in which she can hold conversation whole days with those that can speak her own language. I could understand some of her words, but could not comprehend a period, for it seemed to be but a confused noise. She knows nothing that is said to her, unless she seeth the motion of their mouths that speak to her ; so that in the night, when it is necessary to speak to her, they must light a candle. Only one thing appeared the strangest part of the whole narration : She hath a sister, with whom she hath practised her language more than with any other : And in the night, by laying her hand on her sister’s mouth, she can perceive by that what she saith, and so can discourse with her in the night.’ *Bishop Burnet’s Let. 4. p. 248.*

near the common sensory in the brain, to give the more speedy information; in a part where it can be best guarded, and where it is most free from annoyances and harms itself; and where it gives the least annoyance and hindrance to the exercises of any other part; in a part appropriated to the peculiar use of the principal senses, in the most lofty, eminent part of the body, where it can perceive the most objects, and receive the greatest information: And lastly, in a part of the neighbourhood of its sister sense the eye, with whom it hath peculiar and admirable communication by its nerves, as I intend to shew in its proper place. In respect then of its situation and place in the body, this sense is well designed and contrived, and may so far be accounted the work of some admirable artist. But,

2. If we survey its fabrick and parts, it will appear to be an admirable piece of the divine wisdom, art, and power. For the manifestation of which, let us distinctly survey the outward and the inward part of its curious organ.

1. For the outward Ear: If we observe its structure in all kinds of animals, it must needs be acknowledged to be admirably artificial, it being so nicely prepared, and adjusted to the peculiar occasions of each respective animal. In man (*b*), it is of a form proper for

(*b*) I cannot but admire that our most eminent modern anatomists should not agree, whether there be any muscles in the outward ear of man or not.

Dr.

for the erect posture of his body. In birds, of a form proper for flight; not protuberant, because that would obstruct their progress, but close and covered, to afford the easier passage thro' the air. In quadrupeds, its form is agreeable to the posture, and slower motion of their bodies; and in these too, various, according to their various occasions. In some large, erect,

Dr. Keil saith there are two; Dr. Drake the same number; and Dr. Gibson makes them to be four. So also doth Monsieur Dionis, and so did the ancient anatomists: But Dr. Schelhammer expressly denies there are any, and saith, 'Seduxit autem reliquos  
' brutorum anatome, in quorum plerisque tales  
' muscoli plures inveniuntur; putarunt autem for-  
' tassis ignominiosum homini, si non & his instruc-  
' tus esset, & minùs inde perfectum animal fore.'

Schel, *de auditu*, p. 1. c. 1. § 7. But Valsalva, who wrote very lately, and is very accurate in his survey of the ear, saith, 'Musculi auriculæ posteriores quando-  
' que quatuor, quandoque duo; sed ut plurimum  
' tres adnotantur; & quando solùm duo se mani-  
' festant, tunc unus ex illis duplicato tendine ver-  
' sùs concham deferri solet. Horum musculorum  
' in numero varietatem non solùm in diversis, verum  
' etiam in eodem subjecto quandoque vidi.----- Ex  
' quibus differentiis subortæ sunt auctororum discre-  
' pantia in horum musculorum numero, & po-  
' situ:----- quod non evenisset, si pluries in diversis  
' corporibus iidem muscoli quæsitæ essent.' Ant.  
Mar. Valsalva *de Aur. human. c. 1. § 6.* But Dr. Drake thinks some of Valsalva's muscles the product of fancy. Mr. Cowper makes them to be three, one Attollent, and two Retrahent muscles. See *Anat. Tab. 12.*



erect, and open, to hear the least approaches of dangers (c) ; in others covered, to keep out noxious bodies. In the subterraneous quadrupeds, who are forced to mine and dig for their food and habitation, as a protuberant ear, like that of other quadrupeds, would obstruct their labours, and be apt to be torn and injured ; so they have the contrary (d), their ears

(c) Inter cætera [animalia aurita] maximè admirabilis est auris leporinæ fabrica, quod cum timidissimum animal sit, & prorsus inerme, natura id tum auditu acutissimo, tanquam hostium exploratore ad præsentienda pericula, tum pedibus cæu armis ad currendum aptis munisse videtur.

A. Kircher's *Phonurg.* l. 1. § 7. *Tecnasf.* 2.

(d) Moles have no protuberant ear, but only a round hole between the neck and shoulder ; which situation of it, together with the thick, short fur that covers it, is a sufficient defensive against external annoyances. The Meatus Auditorius is long, round, and cartilaginous, reaching to the under part of the skull. Round the inside runs a little ridge, resembling two threads of a skrew ; at the bottom whereof is a pretty inlet leading to the drum, made on one side, with the aforefaid cochleous ridge, and on the other, with a small cartilage. I observed there was Cerumen in the Meatus.

As to the inner ear, it is somewhat singular, and different from that of the other quadrupeds, and much more from birds ; altho' I have met with some authors that make it agreeable with that of birds. There are three small bones only (all hollow) by which the Drum (to use the old appellation) or the Membrana Tympani (as others call it)

ears short, lodged deep and backward in their head, and passing to the under part thereof, and all sufficiently fenced and guarded. And as for insects, reptiles, and the inhabitants of the waters, if they enjoy this sense (as there is great reason to think they do) it may probably be lodged commodiously under the same security and guard, as the smelling, or some other sense is. And

acteth upon the Auditory Nerve. The first is the Malleus, which hath two processes nearly of equal length; the longer of which is braced to the Membrana Tympani, the shorter to the side of the Drum or Os Petrosum; the back part of it resembles the head and stalk of a small Mushroom, such as are pickled. On the back of the Malleus lies the next small bone, which may be called the Incus, long, and without any process, having somewhat the form of the short scoop wherewith watermen throw the water out of their wherries. To the end of this the third and last small bone is tacked by a very tender brace. This little bone bears the office of the Stapes, but is only forked without any base. One of these forks is at one Fenestra or Foramen, the other at another; in which Fenestræ I apprehend the forks are tacked to the Auditory Nerve. These Fenestræ (equivalent to the Fenestra Ovalis, and Rotunda in others) are the inlets into the Cochlea and Canales Semicirculares, in which the Auditory Nerve lieth. The Semicircular Canales lie at a distance from the Drum, and are not lodged (as in other animals) in a strong, thick body of bone, but are thrust out, within the skull, making an Antrum, with an handsome arch leading into it, into which a part of the brain enters.

And moreover, as the form of this organ is various in various animals, so in each of them its structure is very curious and observable, being in all admirably contrived to collect the wandering, circumambient impressions and undulations of sound, and convey them to the sensory within. If I should run over the several Genera of animals, we might find a notable prospect of the handy-work of God (e), even in this so inconsiderable a part of

One leg of the Malleus being fasten'd to the Membrana Tympani, and the Incus to the back of the Malleus, and the top of that to the top of the Stapes, and the forks or branches of the Stapes to the Auditory Nerve, I observed that whenever I moved the membrane, all the little bones were at the same time moved, and consequently the Auditory Nerve thereby affected also.

I hope the reader will excuse me for being so particular in this organ only of the Mole, a despised creature, but as notable an example of God's work, as its life is different from that of other quadrupeds; for which reason it partly is that I have enlarged on this part differing from that of others, and which no body that I know of, hath taken much notice of, and which is not discoverable without great patience and application; and partly because by comparing these observations with *book vii. chap. 2. note (d)*, we may judge how the sense of hearing is performed.

(e) ' Among many varieties, both in the inner and outer ear, those which appear in the passage into the rock bone, are remarkable. For in an Owl, that perches on a tree or beam, and hears

of animals. But I shall only carry my survey to that of Man. And here the first thing that offereth itself to our view, is the Helix, with its tortuous cavities, made to stop, and collect the sonorous undulations, to give them a gentle circulation and refraction, and so convey them to the Concha, or larger and more capacious round cell at the entrance of the ear. And to bridle the evagation of the sound, when arrived so far, but withal not to make a confusion thereof, by any disagreeable percussions, we may take notice of a very curious provision in those little protuberances, called the Tragus, and Antitragus of the outward ear, of a commodious form and texture (f), and conveniently lodged for this use.

The

\* kens after the prey beneath her, it is produced  
 \* farther out above than it is below, for the better  
 \* reception of the least sound. But in a Fox, that  
 \* scouteth underneath the prey at roost, it is for  
 \* the same reason produced farther out below. In  
 \* a Pole-cat, which hearkens strait forward, it is  
 \* produced behind, for the taking of a forward  
 \* sound. Whereas in a Hare, which is very quick  
 \* of hearing, and thinks of nothing but being pursued, it is supplied with a bony tube, which as a  
 \* natural otocaustick, is so directed backward, as  
 \* to receive the smallest and most distant sound  
 \* that comes behind her.' Grew's *Cosmolog. Sacr.*

*Ib.* 1. c. 5. § 6.

(f) The texture of the Tragus and Antitragus, is softer than that of the Helix, which serveth gently to blunt, but forcibly to repel the sound in the Concha.

The great convenience and benefit of this form and contrivance of the outward ear, is sufficiently manifest by the want thereof, which causeth a 'confusion in the hearing, with a certain murmur, or swooning, like the fall of waters (g).'

Another wise provision of the Creator, is in the substance of the outward ear, which is cartilaginous, the fittest for this place. For (as an ingenious anatomist (b) observes) 'If it had been bone, it would have been troublesome, and might, by many accidents, have been broken off: If flesh, it would have been subject to contusion.' But indeed a worse consequence than this would have ensued such a softness as that of flesh, and that is, it would neither have remained expanded, neither would it so kindly receive and circulate the sounds, but absorb, retard, or blunt their progress into the inward organ. But being hard, and curiously smooth and tortuous, sounds find an easy passage, with a regular volutation and refraction: As in a well-

(g) Dr. Gibson's Anatomy, chap. 22. book iii.

'Those whose ears are cut off, have but a confused way of hearing, and are obliged either to form a cavity round the ear with their own hands, or else to make use of a horn, and apply the end of it to the inner cavity of the ear, in order to receive the agitated air. 'Tis likewise observed, that those whose ears jut out, hear better than flat-eared persons.' *Mons. Dionis's Anat. demonstr. 8.*

(b) Gibson *ibid.*

well-built arch, grotto, or musical instrument, which magnify and meliorate sounds; and some of which convey even a whisper to a large distance (i): But from the outward, let us carry our survey,

## 2. To

(i) It would nauseate the reader to reckon up the places famed for the conveyance of whispers, such as the prison of *Dionysius* at *Syracuse*, which is said to increase a whisper to a noise; the clapping one's hands to the sound of a cannon, &c. Nor the *Aquæducts* of *Claudius*, which carry a voice sixteen miles, and many others both ancient and modern. If the reader hath a mind to be entertained in this way, he may find enough in *Kircher's Phonurgia*. But it may not be irksome to mention one or two of our own in *England*. Among which, one of the most famed is the *Whispering-Place* in *Gloucester Cathedral*, which is no other than a gallery above the east-end of the choir, leading from one side thereof to the other. It consisteth (if I mistake not) of five angles and six sides, the middlemost of which is a naked, uncovered window, looking into a chapel behind it. I guess the two whisperers stand at about twenty-five yards distance from one another. But the *Dome* of *St. Paul's London*, is a more considerable *Whispering-Place*, where the ticking of a watch (when no noise is in the streets) may be heard from side to side; yea, a whisper may be sent all round the *Dome*. And not only in the gallery below, but above upon the scaffold, I tried, and found that a whisper would be carried over one's head round the top of the arch, notwithstanding there is a large opening in the middle of it, into the upper part of the *Dome*.



2. To the inward part of this admirable organ. And here we find the most curious and artful provision for every emergency and occasion. The Auditory Passage, in the first place, curiously tunnelled, and artfully turned, to give sounds an easy passage, as well as a gentle circulation and refraction; but withal, so as to prevent their too furious rushing in, and assaulting the more tender parts within.

And forasmuch as it is necessary that this passage should be always open, to be upon the watch (*k*); therefore to prevent the invasion of noxious insects, or other animals {who are apt to make their retreat in every little hole} nature hath secured this passage (*l*) with a bitter  
nauseous

(*k*) ‘*Auditus autem semper patet: ejus enim sensu etiam dormientes egemus: A quo cum sonus est acceptus, etiam è somno excitamur. Flexuosum iter habet, nè quid intrare possit, si simplex, & directum pateret; provisum etiam, ut si qua minima bestiola conaretur irrumperè, in sordibus aurium, tanquam in visco, inhæresceret.*’  
*Cic. de nat. deor. l. 2. c. 57.*

It deserves a particular remark here, that in infants in the womb, and newly born, the Meatus Auditorius is shut up very closely, partly by the constriction of the passage, and partly by a glutinous substance, whereby the Tympanum is guarded against the water in the Secundine, and against the injuries of the air as soon as the infant is born.

(*l*) It is remarkable that in most, if not all animals, whose ears are tunnelled, or where the Meatus Auditorius is long enough to afford harbour

nauseous excrement (*m*) afforded from the glands (*n*) appointed for that purpose.

From hence let us approach the most inward parts, in which we shall see strokes of the most exquisite art. To pass over the innate air, that

to Ear-wigs, or other insects; that, I say, in the ears of such, Ear-wax is constantly to be found. But in birds, whose ears are covered with feathers, and where the Tympanum lies but a little way within the skull, no Ear-wax is found, because none is necessary to the ears so well guarded, and so little tunnelled.

(*m*) The Ear-wax was thought, by the old anatomists, to be an excrement of the brain: 'Humor biliosus à cerebro expurgatus,' the *Bartholines* say of it, *l. 3. c. 9.* But as *Schelhammer* well observes, 'Nil absurdius, quàm cerebri excrementum hoc statuere. Nam & ratio nulla suadet, & in cerebro fieri excrementum tale credamus: -----neque vix patent per quas ab eo seclusum in meatum auditorium possit inde penetrare.' As to its taste, *Casseri* gives instances of its being sweet in some creatures. But *Schelhammer* says, 'Ego verò semper, cum amaritie aliquid dulcedinis in illo deprehendi.' *Vide Schel. de audit. p. 1. c. 2. § 10.* But I could never distinguish any sweetness in it, but think it insipid mixed with a bitterness.

(*n*) 'Cerumina amara arteriolis exudantia,' *Willis de anim. brut. par. 1. c. 14.* 'In the skin---are little glands, which furnish a yellow and bitter humour.' *Monfieur Dionis's dem. 18.* An handsome cut of those Glandulæ Ceruminosæ is in *Dr. Drake, from Valsalva.*

that most authors talk of (o) (because there is  
no

*Pliny* attributes a great virtue to the Ear-wax ;  
‘ *Morsus hominis inter asperrimos numeratur : me-  
‘ dentur sordes ex auribus : ac ne quis miretur,  
‘ etiam scorpionum ictibus serpentiumque statim  
‘ impositæ.*’ *Plin. nat. hist. l. 28. c. 4.* And that  
it hath an healing quality, and may be accounted a  
good balsam, I myself have experienced.

(o) That there is such a thing as the innate air  
(talked of much by most authors on this subject)  
*Schelhammer* very justly, I think, denies ; by reason  
there is a passage into the inner ear, from the throat,  
through which the innate air may pass out, and the  
outward air enter in. *Vide Par. Alt. p. 2. c. 3. § 10.*  
When by stopping our breath, and straining, we  
force the external air into the ear, it may be heard  
rushing in ; and if much be forced in, it may be  
felt also to beat against the Tympanum. When  
the passage to the throat is by any means stopped,  
as by a cold in the head, &c. the hearing thereby  
becomes dull and blunt ; by reason the communica-  
tion between the outward and inward air is ob-  
structed : but when by strong swallowing, or such  
like motion of the throat, the passage is opened, we  
perceive it by a sudden smack or crack, and we im-  
mediately hear very clearly ; the load of feculent  
air being at that time discharged from the in-  
ner ear.

It is a wise provision, that the passage for the air  
into the ear, is from the throat ; ‘ *Ut non statim  
‘ quivis aer externus irrumpere queat* (as *Schel-  
‘ hammer* saith, *Par. ult. c. 4. § 8.*) sed nonnihil  
‘ immutatus, ac temperatus, calore ex medio ven-  
‘ tre expirante ; imo fortassis non facile alius, nisi  
‘ ex pulmonibus.

no such) the passage to the palate (*p*), and their uses, with divers other curious things that might be named; let us stop a little at the part containing the rest, namely the bone (*q*). The particular texture and hardness of which, above other bones of the body, is very remarkable; whereby it serves not only as a sub-

(*p*) *Valsalva* hath given us a more accurate description of the Tuba Eustachiana, or Passage to the Palate, than any other author; to whom I therefore refer, *De aur. human.* chap. 2. § 16. &c.

The chief use hereof, he thinks, is to give way to the inner air, upon every motion of the Membrana Tympani, the Malleus, Incus, and Stapes. This passage if it be shut up, deafness ensues: Of which he gives two instances: One a gentleman, who lost his hearing by a polypus in the nose reaching to the Uvula; the other a yeoman, labouring with an ulcer above the left side of the Uvula: which when he stopped with a tent dipped in medicine, he lost his hearing in the left ear, and recovered it, as soon as the tent was out. *Ibid.* c. 5. §. 10.

(*q*) 'Os [petrosum] ex quo interiores [Labyrinthi] cavitatum parietes conflati sunt, album, durissimum, necnon maxime compactum. Id autem à naturà ita comparatum esse videtur, ut materia ætherea sonorum objectorum impressionibus onusta, dum prædictis impingitur parietibus, nihil aut saltem fere nihil motus sui amittat, atque adeò illum qualem ab objectis sonoris accepit, talem communicet spiritui animali contento intra expansiones rami mollioris nervorum auris.' *Dr. Raym. Vieussens of Montpellier, in Philos. Transf.* N° 258.

substantial guard to the sensory, but also to oppose the impulses of the ætherial matter, that there may be no loss nor confusion in the sound; but that it may be convey'd regularly, and entirely to the auditory nerves.

The next part I shall take notice of, may be that fine membrane called the Tympanum, or Membrana Tympani (r), with its inner membrane (s); together with the four little appen-

(r) The Tympanum of the ear, or, as *Valsalva* and the moderns, the Membrana Tympani, was taken notice of as early as *Hippocrates's* time. In birds, it is strained towards the outward parts; in other animals towards the brain, or inner parts. Monsieur *Dionis* saith, 'It is not equally fastened to the whole circumference of the bony circle, in which it is inched; for on the upper side it hath a free disengaged part, by which some can give vent to the smock in their mouth.' *Demonstr.* 8. That there is some passage I doubt not, but I question whether Monsieur *Dionis* ever saw the disengaged part he mentions. I have myself carefully searched divers subjects, and do not remember to have seen any such passage; and I perceive it escaped the diligent *Schelhammer's* eye. *Valsalva* also, by injecting in through the Tuba Eustachiana, could not force any liquor into the Meatus Auditorius; but yet he imagines he found the passage out in another place of the drum, in some morbid, and one sound head. *Valsalv. de aur. hum. c. 2. § 8.* Mr. *Cowper* also affirms there is a passage by the upper part of the membrane. *Anat. ap. fig. 8.*

(s) Dr. *Vicussens*, before-named, discovered a membrane, 'tenuissimæ raræque admodum texturæ intra

appendent bones (*t*), and the three inner muscles to move them, and adjust the whole Compages to the several purposes of hearing,

‘ intra cavitatem Tympani ;’ as he describes it. Whose use he saith is, ‘ 1. Occludens labyrinthi januam impedit ne naturalis purissimus ac subtilissimus aer intra cavitates----communicationem----habeat cum aere crasso. 2. Labyrinthi basin calescit, &c. ubi supra.’ Probably this double membrane may be such, or after the same manner as it is in the Tympanum of birds : Of which see my Observations in *book vii. chap. 2. note (d)*.

(*t*) The four little bones being treated of by all that have concerned themselves about this sense of hearing, since their discovery, I shall take notice of only two things concerning them. 1. The discovery of them is wholly owing to the diligence and sagacity of the latter ages ; of which *Schelhammer* gives this account from *Fallopious* : ‘ Hæc officula antiquis anatomicis-----ignota fuere ; primusque qui in lucem produxit [Malleum & Incudem] fuit Jac. Carpenfis ; primus quoque procul omni dubio anatomicæ artis, quam Vesalius postea perfecit, restaurator. Tertium [Stapedum] invenit ac promulgavit primus Joh. Phil. ab Ingrassia, Siculus, Philosophus, ac Medicus doctissimus. Quartum, Thomâ Bartholino teste, viro longè celeberrimo, Fran. Sylvio debetur.’ *Schel.* ubi supra, *cap. iii. § 9.* 2. Their Difference in animals : In Man and Quadrupeds, they are four, curiously inarticulated with one another ; with an external and internal muscle to draw, or work them, in extending or relaxing the Drum ; but in Fowls the case is very different : ‘ His unum officulum



to hear all manner of sounds, loud or languid, harsh or grateful (*u*).

From

‘ solum largita est natura, quod mobilis, quæ in  
 ‘ tympanum videtur terminari. *Id. ib.* § 8. Co-  
 ‘ lumellam forè appellaveris : teres enim est & sub-  
 ‘ tilissimum, basi innitens latiori, rotundæ. Huic  
 ‘ adnexa est cartilago valde. In the ears of all the  
 ‘ Fowl that I could examine, I never found any  
 ‘ more than one bone, and a cartilage, making a  
 ‘ joint with it, that was easily moveable. The Car-  
 ‘ tilage had generally an Epiphyse, or two, one on  
 ‘ each side.-----The bone was very hard and small,  
 ‘ having at the end of it a broad plate, of the same  
 ‘ substance, very thin, upon which it rested, as on  
 ‘ its basis.’ *Dr. Al. Moulen in Phil. Trans. N<sup>o</sup> 100.*

These are the most material things I find ob-  
 served by others, concerning the ears of fowls, and  
 some of them hardly, I believe, observed before.  
 To which I shall subjoin some other things I have  
 myself discovered, that I presume escaped the eyes  
 of those most curious and inquisitive anatomists, of  
 which see the last cited *book vii. chap. 2. note (d).*

(*u*) ‘ Videtur quod tympanum auditionis instru-  
 ‘ mentum præliminare, & quasi præparatorium fu-  
 ‘ erit, quod soni impressionem, sive species sensi-  
 ‘ biles primo suscipiens, eas in debitâ proportionem,  
 ‘ & aptâ conformitate, versùs sensorium, quod ad-  
 ‘ huc interius situm est, dirigat : simili officio fun-  
 ‘ gitur respectu auditûs, ac tunicæ oculi pupillam  
 ‘ constituentes, respectu visûs ; utræque membra-  
 ‘ næ, species sensibiles refringunt & quasi emol-  
 ‘ liunt, easque sensorio non nisi proportionatas tra-  
 ‘ dunt, cui nudo si adveniant, teneriorem ejus cra-  
 ‘ sin faciliè lædant, aut obruant. Reverà tympa-  
 ‘ num non audit, sed meliori tutiorique auditioni

con-

From this region of the Tympanum, I might

‘ confert. Si hæc pars destruat, fenſio adhuc  
 ‘ aliquamdiu, rudi licet modo, peragi poſſit; quippe  
 ‘ experimento olim in cane factò, &c.----Janitoris  
 ‘ officio ut tympanum rectè deſungi poſſit, expan-  
 ‘ ſum ejus pro datâ occaſione ſtringi, aut relaxari  
 ‘ debet, veluti nimirum oculi pupilla---Quapropter  
 ‘ huic auris tympano, non ſecus ac bellico, machi-  
 ‘ næ ſive tæniæ quædam apponuntur, quæ ſuper-  
 ‘ ficieſ ejus modo tenſiorem, modò laxiorem red-  
 ‘ dant: hoc enim efficiunt tria offacula, cum muſ-  
 ‘ culo, &c.’ Willis *de Anim. brut. cap. 14.*

For this opinion of Dr. Willis, Dr. Schelhammer is very ſevere upon him, deriding the refractions he ſpeaks of; and therefore ſeriously proves that they are the humours, not tunicks of the eye, that reſract the rays of light; and then jeeringly demandeth, Whether the ſonorous rays are reſracted by paſſing through a different Medium? Whether the convexity or concavity of the Drum collects thoſe rays into a focal point, or ſcatters them? &c. And then ſaith, ‘ Ob has rationes à clariff. viri, ac  
 ‘ de re medicâ præclare meriti, ſententiâ non poſ-  
 ‘ ſumus non eſſe alieniores; in quo uti ingenium  
 ‘ admiror, quoties medicamentorum vires, aut  
 ‘ morborum cauſas explicat, ſic ubi forum ſuum  
 ‘ egreſſus, philoſophum agit, ac vel partium uſum,  
 ‘ vel chymicarum rerum naturam ſcrutetur, ejus  
 ‘ haud ſemel non modò judicium deſidero, verum  
 ‘ aliquando etiam fidem.’ This is ſo ſevere and unjuſt a cenſure of our truly famous countryman (a man of known probity) that might deſerve a better anſwer; but I have only time to ſay, that although Dr. Schelhammer hath out-done all that wrote before him, in his book *de Auditu*, and ſhewed himſelf a  
 man

man of learning and industry ; yet as our country-man wrote more than he (though perhaps not free from errors too) so he hath manifested himself to have been as curious and sagacious an anatomist, as great a philosopher, and as learned and skilful a physician, as any of his censurers, and his reputation for veracity and integrity, was no less than any of theirs too. But after all this terrible clamour, Dr. *Scbelhammer* prejudicately mistaketh Dr. *Willis's* meaning, to say no worse. For by 'utræque membræ refringunt,' Dr. *Willis* plainly enough, I think, means no more than a restriction of the ingress of too many rays ; as his following explanatory words manifest, viz. 'refringunt, & quasi emolliunt, easque sensorio non nisi proportionatas tradunt.' But indeed Dr *Scbelhammer* hath shewn himself a too rigid censor, by making Dr. *Willis* say, the Ear-drum hath such like braces as the War-drum ; viz. 'Quod porrò de machinis seu tæniis tympani bellici adducit, dicitque idem in tympano auditorio conspici, id prorsus falsissimum est.' I wonder Dr. *Scbelhammer* did not also charge Dr. *Willis* with making it a porter, since he hath in the same paragraph, 'Junitoris officio,' &c. But Dr. *Willis's* meaning is plain enough, that the little bones and muscles of the Ear-drum do the same office in straining and relaxing it, as the braces of the War-drum do in that. And considering how curious and solemn an apparatus there is of bones, muscles and joints, all adapted to a ready motion, I am clearly of Dr. *Willis's* opinion, that one great use of the Ear-drum is for the proportioning sounds, and that by its extension and retraction, it corresponds to all sounds, loud or languid, as the pupil of the eye doth to several degrees of light : and that they are no other than secondary uses assign'd by Dr. *Scbelhammer*,

*hammer*, as the principal or sole uses of keeping out the external colder air, dust, and other annoyances; but especially that, 'Ob solius aeris interni potissimum irrumpentis vim, hunc motum tympani ac mallei esse conditum, ut cedere primum, deinde sibi restitui queat;' as his words are, *P. ult. c. 6. § 13.*

It was no improbable thought of *Robault*, 'Nos attentos præbere, nil aliud est, nisi Tympanum, ubi ita opus est facto, contendere aut laxare, & operam dare ut illud in eâ positione intentum stet, in quâ tremulum aeris externi motum commodissimè excipere possit.' *Roh. Phys. p. 1. c. 26. § 48.*

The hearing of deaf persons more easily by means of loud noises, is another argument of the use of the straining or relaxation of the Tympanum in hearing. Thus Dr. *Willis* (*ubi supra*) Accepi olim à viro fide digno, se mulierem novisse, quæ licet surda fuerit, quousque tamen intra conclave tympanum pulsaretur, verba quævis clarè audiebat: quare maritus ejus tympanistam pro servo domestico conducebat, ut illius ope, colloquia interdum cum uxore suâ haberet. Etiam de alio surdastro mihi narratum est, qui prope campanile degens, quoties unâ plures campanæ resonarent, vocem quamvis facilè audire, & non aliàs, potuit.

'Abscisso musculo [processus majoris mallei] in recenti aure, relaxatur [tympani membrana]' *Valsalv. de Aur. hum. c. 2. § 5.*

Upon considering the great difference in authors' opinions, about the use of the parts, and manner how hearing is performed, as also what a curious provision there is made in the ear, by the four little bones, the muscles, membrane, &c. I was minded (since I penned this note) to make enquiry myself into this part, and not to rely upon authority.

might pass to that of the Labyrinth (*w*), and therein survey the curious and admirable structure of the Vestibulum, the Semicircular Canals (*x*), and Cochlea; particularly the artificial

ity. And after a diligent search of various subjects, I find we may give as rational and easy an account of hearing, as of seeing, or any other sense; as I have shewn in my last cited note (*d*), *book vii. chap. 2.* with relation to birds. And as to men and beasts, the case is the same; but the apparatus more complex and magnificent. For whereas in birds, the auditory Nerve is affected by the impressions made on the Membrane, by only the intermediacy of the Columella; in man, it is done by the intervention of the four little bones, with the muscles acting upon them; his hearing being to be adjusted to all kinds of sounds, or impressions made upon the Membrana Tympani. Which impressions are imparted to the auditory Nerve in this manner; viz. First they act upon the Membrane and Malleus, the Malleus upon the Incus, and the Incus upon the Os Orbiculare and Stapes; and the Stapes upon the auditory Nerve: For the base of the Stapes (the same as the Operculum in birds) not only covers the Fenestra Ovalis, within which the auditory Nerve lieth, but hath a part of the auditory Nerve spread upon it too. It is manifest that this is the true process of hearing; because if the Membrane be mov'd, you may see all the bones move at the same time, and work the base of the Stapes up and down in the Fenestra Ovalis, as I shewed in this chapter, note (*d*), concerning the Mole; and as it may be seen in other ears carefully opened, if the parts remain *in situ*.

(*w*) I do not confine the Labyrinth to the Canals Semicirculares, or any other part, as the elder anatomists

ficial gyrations, and other singular curiosities observable in the two latter.

But I shall not expatiate on these reclude parts; only there is one special contrivance of the nerves ministring to this sense of hearing, which must not be passed by; and that is, the branches of one of the auditory Nerves (y),  
spread

anatomists seem to have done, who by their erroneous and blind descriptions seem not well to have understood these parts; but with those much more curious and accurate anatomists, Monsieur *de Verney*, and Dr. *Valsalva*; under the Labyrinth, I comprehend the Canales Semicirculares, and the Cochlea, together with the intermediate cavity, called by them the Vestibulum.

(x) In the semicircular Canals, two things deserve to be noted. 1. That the three canals are of three different sizes, Major, Minor, and Minimus, 2. Although in different subjects they are frequently different, yet in the same subject they are constantly the same, the reason of all which, together with the uses, *Valsalva* ingeniously thinks is, that as a part of the tender auditory nerve, is lodged in these canals, so they are of three sizes, the better to suit all the variety of tones; some of the canals suiting some, and others, other tones. And although there be some difference as to the length and size of these canals, in different persons, yet lest there should be any discord in the auditory organs of one and the same man, those canals are always in exact conformity to one another in one and the same man. *Vide Valsal. ubi supr. c. 3. § 7. and c. 6. § 4, 9.*

(y) 'Hic posterior nervus extra cranium delatus, in tres ramos dividitur, qui omnes motibus  
' patho-



spread partly to the muscles of the ear, partly to the eye, partly to the tongue and instruments of speech, and inoculated with the nerves to go to the heart and breast. By which means there is an admirable and useful consent between these parts of the body; it being natural for most animals, upon the hearing any uncouth sound, to erect their ears, and prepare them to catch every sound; to open their eyes (those constant faithful sentinels) to stand upon their watch; and to be ready with the mouth to call out, or utter what the present occasion shall dictate. And accordingly it is very usual for most animals, when surpriz'd and terrify'd with any noise, presently to shriek and cry-out.

But there is besides this, in man, another great use of this nervous commerce between the ear and the mouth; and that is (as one of the best authors on this subject expresseth it)

That

patheticis-----inserviunt. Primus----- musculis  
 auris impenditur. Proculdubio hujus actione ef-  
 ficitur, ut animalia quævis, à subito soni impulsu,  
 aures quasi sonum nimis citò transeuntem capta-  
 turas erigant. Ramus alter-----versus utrumque  
 oculi angulum surculos emittit: pui musculis pal-  
 pebrarum attollentibus inseruntur; quorum certè  
 munus est ad subitum soni appulsum oculos con-  
 festim aperire, eosque velut ad excubias vocare.---  
 Tertius-----ramus versus linguæ radicem descen-  
 dens, musculis ejus & ossis hyoideos distribuitur,  
 adeoque organa quædam vocis edendæ actuat, &c.

Willis's *Cereb. anat.* cap. 17.

‘ That (z) the voice may correspond with the hearing, and be a kind of echo thereof, that what is heard with one of the two nerves, may be readily expressed with the voice, by the help of the other.’

Thus much may suffice to be said concerning the organ. Let us

II. Take notice of the Object of this admirable sense, namely, Sound; and so conclude this chapter. I shall not here enquire into the nature and properties of sound, which is in a great measure intricate, and hath puzzled the best naturalists: Neither will I show how this admirable effect of the divine contrivance may be improved to divers uses (aa) and

(z) ‘ Hujusmodi nervorum conformatio in homine usum alium insigniorem præstat, nempe ut vox, &c.’ Willis *ibid.*

(aa) Among the uses to which the wit of man hath employ’d sounds, we may reckon the instruments useful in convoking assemblies, managing armies, and many other occasions, wherein bells, trumpets, drums, horns, and other sounding instruments are used; the particularities of which it would be tedious to recount: As that the biggest Bell in Europe is reckon’d to be at *Erfurt* in Germany, which they say may be heard twenty four miles; with much more to the same purpose. I shall therefore only for a sample take notice of the Speaking Trumpet; the invention of which is commonly ascribed to our eminent Sir Samuel Merland; but was more probably *Art. Kircher’s*: at least, he had contrived such an instrument, before Sir Samuel hit upon his.

and purposes in human life; but my business will be to shew that this thing, of so admirable

*Kircher* in his *Phonurg*, saith, the *Tromba* published last year in *England*, he had invented twenty-four years before, and published in his *Misurgia*; that *Jac. Albanus Ghibbessius*, and *Fr. Eschinardus* ascribe it to him; and that *G. Scottus* testifieth he had such an instrument, in his chamber in the *Roman College*, with which he could call to, and receive answers from the porter. And considering how famed *Alexander the Great's* tube was, which is said might be heard 100 Stadia, it is somewhat strange that nobody sooner hit upon the invention. Of this *Stentorophonick Horn* of *Alexander*, there is a figure preserved in the *Vatican*, which, for curiosity sake, I have from *Kircher* represented in fig. III. He saith its diameter was five cubits, and that it was suspended on a supporter.

For the make of the Speaking Trumpet, and the reason why it magnifies sounds, I shall refer to *Kircher*; especially to *Sir Samuel Morland's Tube Stentorophonica*, published in 1672.

*Kircher* saith, he took one of these trumpets of fifteen palms length, along with him to the *Mon. Eustachianus*, where he convoked 2200 persons to prayers, by means of the unusual Sound, at two, three, four, and five *Italian* miles distance.

With these Bellowing-Trumpets, I shall join some Bellowing-Caves for the reader's diversion. *Ol. Magnus* describes a cave in *Finland*, near *Viburgh*, called *Smellen*, into which, if a dog, or other living creature be cast, it sends forth so dreadful a sound, that knocks down every one near it. For which reason they have guarded the cave with high walls to prevent the mischiefs of its noise. *Vide Ol. Magn.*

ble use in the animal world, is the work of God. And this will appear, let the subject matter of sounds be what it will; either the atmosphere (*bb*) in gross, or the ætherial part thereof,

*hist. l. 11. c. 4.* Such another *Peter Martyr* saith is in *Hispaniola*, which, with a small weight cast into it, endangers deafness at five miles distance. And in *Switzerland Kircher* saith, in the *Cucumber-Mountains* is a pit that sends out both a dreadful noise and a great wind therewith; and that there is a well in his country 3000 palms deep, whose sound is equal to that of a great gun. *Vide Kirch. Phonurg.*

*Ol. Magnus*, speaking of the vast high mountains of a northern province called *Angermannia*, saith,  
 ‘Ubi bases eorum in profundissimo gurgite stantes,  
 ‘casu aliquo, vel proposito nautæ accefferint, tan-  
 ‘tum horrorem ex altâ fluctuum collisione perci-  
 ‘piunt, ut nisi præcipiti remigio, aut valido vento  
 ‘evaserint, solo pavore ferè exanimés fiant, mul-  
 ‘toque dierum curriculo, ob capitis turbationem,  
 ‘pristinæ mentis, & sanitatis compotes vix eva-  
 ‘dant. Habent bases illorum montium in fluctuum  
 ‘ingressu & regressu tortuosas rimas, sive scissuras,  
 ‘satis stupendo naturæ opificio fabricatas, in qui-  
 ‘bus longâ voragine formidabilis ille sonitus quasi  
 ‘subterraneum tonitru generatur.’ *Ol. Magn.*  
*l. 2. c. 4.* See also *chap. xii.*

(*bb*) That the air is the subject or Medium of sound, is manifest from the experiments in rarified and condensed air. In an unexhausted receiver, a small bell may be heard at the distance of some paces; but when exhausted, it can scarce be heard at the nearest distance: And if the air be compressed, the sound will be louder, proportionably to

thereof, or soniferous particles of bodies, as some fancy, or whatever else the philosophers

the compression or quantity of air crouded in, as I have often tried myself, and may be seen in Mr. *Hawksbee's* curious Experiments, p. 97. Also his Experiments in *Philos. Transact.* N<sup>o</sup> 321.

Neither doth this succeed only in forced rarefactions and condensations of the air, but in such also as are natural; as is evident from *David Frædlicbius* in *Varenius*, upon the highest eminences of *Carpathas*, near *Kesmarckt* in *Hungary*. The story of *Frædlicbius* is this, 'Ego mense Junii 1615. tum  
'adolescens, sublimitatem horum montium, cum  
'duobus comitibus scholaribus, experiri volens,  
'ubi, cum in primæ rupis vertice, magno labore,  
'me summum terminum affecutum esse putarem,  
'demum sese obtulit alia multo altior cautes, ubi  
'per vasta eaque vacillantia saxa (quorum unum,  
'si loco à viatore dimovetur---- aliquot centena---  
'rapit, & quidem tanto cum fragore, ut illi metuendum sit nè totus mons corruat, eumque obruat) enixus essem, iterum alia sublimior prodit, &c. donec summo vitæ periculo ad supremum cacumen penetraverim. Ex declivioribus montibus cum in subjectas valles,----nil nisi obscuram noctem, aut cœruleum quid, instar præfundi aëris, quod vulgò sudum cœlum appellatur, observare potui, mihi quæ videbar, si de monte caderem, non in terram, sed rectè in solum me prolapsurum. Nimia enim declivitate, species visibiles extenuatæ & hebetatæ fuerunt. Cum verò altio rem montem peterem, quasi intra nebulas densissimas hærebam.----Et cum non procul à summo vertice essem, de sublimi quiescens prospexi & animadverti iis in locis, ubi mihi antea  
'videbar

phers may think it. For who but an intelligent Being, what less than an omnipotent and infinitely wise God could contrive and make such

‘ videbar intra nebulas hæsisse, compactas atque  
 ‘ albas sese movere nubes, supra quas, per aliquot  
 ‘ milliaria, & ultra terminos Sepusi commodus mihi  
 ‘ prospectus patuit. Alias tamen etiam nubes al-  
 ‘ tiores, alias item humiliores, necnon quasdam  
 ‘ æqualiter à terrâ distantes vidi. Atque hinc tria  
 ‘ intellexi, 1. Me tum transivisse principium me-  
 ‘ diæ aëris regionis. 2. Distantiam nubium a ter-  
 ‘ ra, non esse æqualem----3. Distantiam nubium---  
 ‘ non 72 mill. Ger. ut quidam----sed tantum dimi-  
 ‘ diatum mill. Ger. In summum montis verticem  
 ‘ cùm pervenissem, alio tranquillum & subtilem  
 ‘ aërem ibi offendi, ut nè pili quidem motum sen-  
 ‘ tirem, cùm tamen in depressioribus ventum vehe-  
 ‘ mentem expertus sim: unde collegi summum ca-  
 ‘ cumen istius montis Carpathici ad mill. Germ. à  
 ‘ radicibus suis imis exsurgere, & ad supremam us-  
 ‘ que aëris regionem, ad quam venti non ascen-  
 ‘ dunt, pertingere. Explosi in eâ summitate Sclo-  
 ‘ petum: quod non majorem sonitum primò præ-  
 ‘ se tulit quàm si tigillum vel bacillum confregis-  
 ‘ sem; post intervallum autem temporis murmur  
 ‘ prolixum invaluit, inferioresque montis partes,  
 ‘ convalles & sylvas opplevit. Discendendo per ni-  
 ‘ ves annosas intra convalles, cùm iterum Sclope-  
 ‘ tum exonerarem, major & horribilior fragor, quàm  
 ‘ ex tormento capacissimo inde exoriebatur: hinc  
 ‘ verebar nè totus mons concussus mecum corruer-  
 ‘ et: duravitque hic sonus per semiquadrantem  
 ‘ horæ, usque dum abstrusissimas cavernas pene-  
 ‘ trasset, ad quas aër undique multiplicatus resi-  
 ‘ liit,-----In his celsis montibus, plerumque ningit



such a fine body, such a medium, so susceptible of every impression, that the sense of hearing hath occasion for, to empower all animals to express their sense and meaning to others ;  
to

‘ grandinatae mediâ æstate, quoties nempe in sub-  
‘ jectâ & vicinâ planitie pluit, uti hoc ipsum exper-  
‘ tus sum. Nives diversorum annorum ex colore  
‘ & cortice duriore dignosci possunt.’ Varen.  
*Geogr. gen. l. 1. c. 19. prop. ult.*

The story being diverting, and containing divers things remarkable, I have chosen to note the whole of it (although somewhat long) rather than single out the passages only which relate to the diminishing the sound of his pistol, by the rarity of the air at that great ascent into the atmosphere ; and the magnifying the sound by the polyphonisms or repercussions of the rocks, caverns, and other phonicamptick objects below in the mount.

But 'tis not the air alone that is capable of the impressions of sound, but the water also, as is manifest by striking a bell under water, the sound of which may plainly enough be heard, but it is much duller, and not so loud ; and it is also a fourth deeper, by the ear of some great judges in musical notes, who gave me their judgments in the matter. But *Mersenne* saith, a sound made under water, is of the same tone or note, if heard under water, as are also sounds made in the air, when heard under water. *Vide Mersen. Hydraul.*

Having mentioned the hearing of sounds under water, there is another curiosity worth mentioning, that also farther proves water to be susceptible of the impressions of sound, *viz.* Divers at the bottom of the sea can hear the noises made above only confusedly : But, on the contrary, those above cannot

to make known their fears, their wants, their pains, and sorrows in melancholick tones; their joys and pleasures in more harmonious notes: to send their minds at great distances (cc),  
in

not hear the divers below. Of which an experiment was made, that had like to have been fatal: One of the divers blew an horn in his diving bell, at the bottom of the sea; the sound whereof (in that compressed air) was so very loud and irksome, that stunned the diver, and made him so giddy, that he had like to have dropt out of his bell, and to have been drowned. *Vide Sturmii Colleg. cur. Vol. II. Tentam. I.*

(cc) As to the distance to which sound may be sent, having some doubt, whether there was any difference between the northern and southern parts, by the favour of my learned and illustrious friend Sir Henry Newton, her late Majesty's Envoy at *Florence*, I procured some experiments to be made for me in *Italy*. His most serene highness the Great Duke, was pleased to order great guns to be fired for this purpose at *Florence*, and persons were appointed on purpose to observe them at *Leghorn*, which they compute is no less than 55 miles in a strait line. But notwithstanding the country between being somewhat hilly and woody, and the wind also was not favouring, only very calm and still, yet the sound was plainly enough heard. And they tell me, that the *Leghorn* guns are often heard 66 miles off, at *Porto Ferraro*; that when the *French* bombarded *Genoa*, they heard it near *Leghorn*, 90 miles distant; and in the *Messina* Insurrection, the guns were heard from thence as far as *Augusta* and *Syracuse*, about 100 Italian miles. These distances  
being

in a short time (*dd*), in loud boations, or to express their thoughts near at hand with a gentle voice, or in secret whispers ! And, to say no more, who less than the same most wise and

being so considerable, give me reason to suspect, that sounds fly as far, or nearly as far, in the southern, as in the northern parts of the world, notwithstanding we have a few instances of sounds reaching farther distances. As Dr. Hearn tells us of guns fired at *Stockholm* in 1685, that were heard 180 English miles. And in the Dutch war, 1672. the guns were heard above 200 miles. *Vide Phil. Transf.* N° 113. Also there is this farther reason of suspicion, that the Mercury in the Barometer riseth higher without than within the tropicks, and the more northerly, still the higher, which may increase the strength of sounds, by note (*bb*).

(*dd*) As to the velocity of sounds, by reason the most celebrated authors differ about it, I made divers nice experiments myself, with good instruments ; by which I found, 1. That there is some, although a small difference, in the velocity of sounds, with or against the wind ; which also is, 2. Augmented or diminished by the strength or weakness of the wind. But that nothing else doth accelerate or retard it, not the differences of day or night, heat or cold, summer or winter, cloudy or clear, barometer high or low, &c. 3. That all kinds of sounds have the same motion, whether they be loud or languid, of bells, guns, great or small, or any other sonorous body. 4. That they fly equal spaces in equal times. Fifthly and lastly, that the mean of their flight is at the rate of a mile in 9 half seconds and a quarter, or 1142 feet in one second of time. *Vide Phil. Transf.* ib.

and indulgent Creator, could form such an oeconomy, as that of melody and musick is: That the Medium should (as I said) so readily receive every impression of sound, and convey the melodious vibration of every musical string, the harmonious pulses of every animal voice, and of every musical pipe; and the ear be as well adapted, and ready to receive all these impressions, as the Medium to convey them: And lastly, that by means of the curious lodgment, and insculcation of the auditory Nerves before-mentioned, the orgasms of the spirits should be allay'd, and perturbations of the mind, in a great measure quieted and stilled (cc):

Or,

(cc) *Timothy* a musician could excite *Alexander the Great* to arms with the *Phrygian* sound, and allay his fury with another tone, and excite him to merriment. So *Ericus* king of *Denmark*, by a certain musician, could be driven to such a fury, as to kill some of his best and most trusty servants. More of this power of musick over the affections, may be seen in *A. Kirch. Pbonurg. lib. 2. § 1.* Also in *Is. Vossius de Poematum cantu, & Rytmi viribus.*

And not only upon the affections, but also on the parts of the body, musick is able to exert its force, as appears from the *Gascoigne* knight, 'Cui Phormingis sono audito vesica statim ad urinam reddendam vellicabatur.' Such another we have in *A° 1. Ephem. nat. curios. observ. 134.* Also *Morhoff de Scyth. vitr. per cert. human. vocis sonum fracto*: where there is not only the account of the Dutchman at *Amsterdam*, one *Nich. Peter*, that brake romer-glasses with the sound of his voice; but also

divers

Or, to express it in the words of the last cited famous

divers other instances of the powers and effects of sound. But to the story of the *Gascoigne* knight, Mr. *Boyle*, from *Scaliger*, adds a pleasant passage, That one he had disobliged, to be even with him, caused at a feast, a bag-pipe to be played, when he was hemmed in with the company; which made the knight be-piss himself, to the great diversion of all then present, as well as confusion of himself. Boyle's *Essay of the effect of lang. motion*. In the same book are other matters that may be noted here. One whose arm was cut off, was exceedingly tormented with the discharge of the great guns at sea, although he was at a great distance on land. And a great ship-commander observed his wounded men, with broken limbs, suffered in like manner at the enemies discharges. An ingenious domestick of his own would have his gums bleed at the tearing of brown paper. And an ingenious gentleman of Mr. Boyle's acquaintance confessed to him, that he was inclined to the Knight of *Gascoigne's* distemper, upon hearing the noise of a tap running. The dancing to certain tunes, of persons bit with the Tarantula, he was assured of by an ingenious acquaintance at *Tarentum*, who saw several, among the rest a physician affected with that distemper. And many other accounts of this kind, seemingly credible, are related in *Morboff*, *Kircher*, and many others; although Dr. *Cornelio* questions the matters of fact relating to the cure of the Tarantula bite, in *Phil. Transf.* N<sup>o</sup> 83. Mr. Boyle also saith, a sober musician told him, he could make a certain woman weep, by playing one tune, which others would be little affected at. And he saith, that he himself

himself had a kind of shivering at the repeating two verses in *Lucan*. And I add, that I very well know one to have a sort of chill about his Præcordia and head, upon reading or hearing the 53d chapter of *Isaiab*; as also *David's* lamentation for *Saul* and *Jonathan*, 2. *Sam.* i.

Neither are our own minds and bodies only affected with sounds, but inanimate bodies are so also. Of which many stories may be met with in *Kircher*, particularly a large stone that would tremble at the sound of one particular organ-pipe; in *Morhoff* also, who among many other relations hath this, 'Mini cùm ipsi [clarif. Willifio] de experimento vitri per vocem fracti narrarem, ex eo audivisse, quòd in ædibus musicis sibi vicinis aliquoties col-lapsum pavementum fuerit; quod ipse sonis continuis adscribere non dubitavit.' *Morhoff. c. 12.*

*Mersenne* also, among many relations in his *Harmon.* and other books, tells a far more probable story of a particular part of a pavement that would shake, as if the earth would open, when the organs played, than what he relates about Antipathy, in his *Quæst. comment. in Genes.* viz. That the sound of a drum made of a wolf's-skin, will break another made of sheep's-skin: that hens will fly at the sound of an harp strung with fox-gut-strings, and more to the same purpose. *Mr. Boyle* also, in his last cited book tells us, seats will tremble at the sound of organs, and that he had felt his hat to do so too under his hand, at certain notes both of organs, and in discourse; that he tried an arch that would answer to C fa-ut, and had done so 100 years; and that an experienced builder told him, any well built vault will answer some determinate note. And at *East-bury House* near *Barking*, I myself discovered the porch (having firm brick-walls) not only to sound when



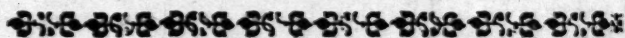
famous author (*ff*), ‘ That musick should not  
 ‘ only affect the fancy with delight, but also  
 ‘ give relief to the grief and sadness of the  
 ‘ heart ; yea, appease all those turbulent  
 ‘ passions, which are excited in the breast, by  
 ‘ an immoderate ferment, and fluctuation of  
 ‘ the blood.’

And now, who can reflect upon all this  
 curious apparatus of the Sense of Hearing,  
 and not give the great Creator his due praise!  
 Who can survey all this admirable work, and  
 not as readily own it to be the work of an  
 omnipotent, and infinitely wise and good  
 God (*gg*), as the most artful melodies we hear,  
 are the voice or performances of a living  
 creature.

when struck on the bottom, but also to give almost  
 as loud a sound, when I sounded the same note with  
 my voice.

(*ff*) Willis, *ubi supra*.

(*gg*) ‘ Ille Deus est-----qui non calamo tantum  
 ‘ cantare, & agreste, atque inconditum carmen ad  
 ‘ aliquam tantum oblectationem modulari docuit,  
 ‘ sed tot artes, tot vocum varietates, tot sonos,  
 ‘ alios spiritu nostro, alios externo cantu edituros  
 ‘ commentus est.’ Senec. *de benef.* l. 4. c. 6.



## C H A P. IV.

### *Of the Sense of Smelling.*

**T**HIS sense I shall dispatch in less com-  
 pass than the two last, because its ap-  
 paratus (although sufficiently grand and admi-  
 rable,

table, yet, is not so multiplicitious as of the eye and ear; it being sufficient in this sense, that the odoriferous effluvia of bodies (*a*) can have an easy, free passage to the olfactory nerves, without the formalities of refractions, and other preparations necessary to the perfection of the two former senses. Accordingly, the all-wise Creator hath made sufficient provision for the reception of smells, by the aperture of the nostrils (*b*); made not of flesh, or bone, but cartilaginous, the better to be kept open, and withal, to be dilated or contracted, as there is occasion: For which service it hath several proper and curious muscles (*c*).

And

(*a*) A piece of Ambergreese suspended in a pair of scales that would turn with a very small part of a grain, lost nothing of its weight in three days and a half; neither did Assafoetida in five days and a half: But an ounce of Nutmegs lost five grains and a half in six days; and Cloves seven grains and four fifths. *Boyle's Subtil. of Effluv. c. 5.*

(*b*) 'Nares, eò quòd omnis odor ad superiora fertur, rectè sursum sunt: Et quòd cibi & potio- nis judicium magnum earum est, non sine causâ vicinitatem oris secutæ sunt.' *Cic. de nat. deer. l. 2. c. 56.*

(*c*) Had not the contriver of animal bodies been minded that his work should have all the signatures of accuracy, this sense might have been performed with a bare aperture of the nose; but that nothing might go imperfect out of his hand, he hath made a part of the nose easily moveable, and given a set of muscles to lift up, and open and shut the nostrils; and so adjust it to every occasion of this sense.

And forasmuch as it is by breathing (*d*), that the odorant particles are drawn in, and conveyed to the sensory ; therefore there is a very wise provision made in the Laminæ, with which the upper part of the nose is barricaded, which serve to two excellent uses : partly, to fence out any noxious substances from entering the breathing passages in our sleep, or when we cannot be aware (*e*) ; and partly, to receive the divarications of the olfactory nerves, which are here thick spread, and which do by these means meet the smells entering with the breath, and striking upon them.

And accordingly, the more accurate this sense is in any animal, the longer we may observe those Laminæ are ; and more of them in number folded up, and crouded together, to contain the more nervous filaments, and to detain and fetter the odoriferous particles in their windings and turnings.

And an admirable provision this is, which the great Creator hath made for the good of  
brute

(*d*) ‘ Odorem non aliud, quàm infectum aëra, intelligi posse.’ Plin. *Nat. hist.* l. 9. c. 7.

(*e*) For a further guard against the ingress of noxious things, the vibrissi, or hairs placed at the entrance of the nostrils serve, which, in some measure stop the entrance of things improper, or, however, give warning of them ; but at the same time allow an easy passage to the breath and odours.

brute creatures (*f*); the chief acts of many of whose lives are performed by the ministry of this sense. In insects, and many other creatures, it is of great use in the propagation of their kind; as particularly in helping them to safe and convenient places for the incubation of their eggs, and breeding up their young. Others are by the accuracy of this sense, of use to mankind, which would be otherwise of little or no use (*g*). And most of the irrational animals, birds, beasts, and creeping things, do, by their smell, find out their food; some at great distances, and some at hand. With what sagacity do some discover their food in the

(*f*) ' Multò præclarius emicat [Olfactus] in brutis animalibus, quàm in hominè: ista namque hoc solo indicè, herbarum, aliorumque corporum prius ignotorum virtutes certissimè dignoscunt, quin & victum solum absentem, vel in abstruso positum, odoratu venantur, ac faciliè investigant. Quòd autem minùs sagaces sunt hominum nares, illud non facultatis hujus abusui (prout nonnulli volunt) ascribi debet, verùm in causà est ipsius organi defectus: hoc enim circa victus humani criteria (ubi ratio, & intellectus adsunt) non ita accuratum requiritur: propterea enim inferiores potentiae in hominè, à naturà minùs perfectæ existunt, ut superiorum cultui & exercitio relinqueretur locus.' Willis *de anim. brut. cap. 13.*

(*g*) Thus the chief use of hounds is to hunt; and other dogs to be a watch and guard to our houses by night. For which services (particularly in hounds) their olfactory nerves are not only remarkably

the midst of mud and dirt (*b*)! With what curiosity do the herbaceous kind pick and chuse such plants as afford them wholesome food, or sometimes such as are medicinal (*i*), and refuse such as would hurt and destroy them! and all by the help principally, if not only, of the smell, assisted by its near ally the taste. Of which I shall in the next place speak very briefly.

ably larger (like as they are in other brutes) but their branches and filaments are, in the Laminæ of the nostrils, both more and larger than I have seen in any other creature whatsoever. Also there are more convulsions of the Laminæ than I ever remember to have found in any other animal.

The sagacity of hounds is prodigious; of which see an instance in *book iv. chap. 11. note (hhh)*.

(*b*) See *book vii. chap. 2. note (e)*.

(*i*) *Vide Plin. Hist. nat. l. 8. c. 27. 'Quæ animalia quas herbas ostenderunt.'*



## CH A P. V.

### Of the Taste (*a*).

**I**N this, as in the last sense, we have an apparatus abundantly sufficient to the sense; nerves curiously divaricated about the tongue,

(*a*) 'Τὰ δὲ εἶδη τῶν χυλῶν, &c. Saporum genera,---  
'dulcis, pinguis, austerus, acerbus, acris, salus,  
'amarus, acidus.' Theophr. *de caus. plant. l. 6. c. 1.*  
What may be the cause of the difference of tastes,

he

what  
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l (i),  
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he

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tongue (b), and mouth, to receive the impressions of every gusto; and these nerves guarded with a firm and proper tegument, to defend them from harms; but withal, so perforated in the papillary eminences, as to give a free admission to tastes.

But

he saith, is hard to assign, 'πότερον γὰρ τοῖς πλάσσει,  
&c. Utrum affectionibus sensuum---- an figuris,  
' quibus singuli constant, ut Democritus censet,  
id. ib. 'Διπλόπικτον δὲ &c. Democritus---- dulcem  
' esse saporem qui rotundus; acerbum qui figurâ  
' magnâ; asperum qui multis angulis, &c. id. ib. &c.  
But of the diversities and causes of tastes, see Dr.  
Grew, *Lect.* 6. and Dr. Willis *de Anim. brut.* c. 12.

(b) 'Intellectus saporum est cæteris in primâ  
' linguâ: Homini, & in palato.' Plin. l. 11. c. 37.

The opinions of the anatomists concerning the organ of Taste are various. *Baubin. T. Bartholin. Bartholette, Veslinge, Deussinge, &c.* place it in the laxer, fleshy parts of the tongue. Our famous *Wharton*, in the gland at the root of the tongue; *Laurentius* in the thick tunick covering the tongue; but the learned *Malpighi* with great probability concludes, because the outward cover of the tongue is perforated, under which lie papillary parts (of which Mr. *Cowper* hath very good cuts in his *Anat. Tab.* 13.) that in these the taste lieth. *Malpighi's* words are, 'Quare cùm dictis meatibus insignibus  
' occurrant papillaria corpora, probabilius est in his  
' ultimo, ex subintranti sapido humore titillationem,  
' & medicationem quandam fieri, quæ Gustum  
' efficiat.' *Malpig. Op. tom. 2. de linguâ, pag. 18.*  
' Præcipuum ac ferè solum gustatûs organon est  
' lingua; cui aliquatenus, subobscurè tamen, palat-



But I shall say no more of this sense ; only a word or two of its consent with the smell, and the situation of them both : Their situation is in the most convenient place imaginable, for the discharge of their offices ; at the first entrance (*c*), in the way to the grand receptacle of our food and nourishment ; to survey what is to be admitted therein ; to judge between what is wholesome, and fit for nourishment, and what is unfavoury and pernicious. And for this end, the all-wise Creator seems to have established a great consent between the eye, the nose, and tongue, by ordering the branches of the same nerves (*d*), to each

‘ tum, & superior gulæ pars consentiunt : in omnibus verò fibræ nervosæ immediata sensationis instrumenta sunt. Quare observare est, linguam præ aliâ quâvis parte insigniter fibrosam esse, etiam texturâ valdè porosâ constare, in eum nempe finem, ut particulæ rei sapidæ copiosius ac penitius intra sensorii meatus admittantur---- nervi autem qui fibris linguæ densissimè intertextis famulantur, ac saporum impressiones τῷ πρώτῳ αἰσθητικῷ communicant sunt----nervi è paribus tum quinto, tum nono ; & ubique cum densâ propaginum serie per totam ejus compagem distributi.’ Willis *ibid*.

(*c*) ‘ Gustatus, qui sentire eorum quibus vescimur genera debet, habitat in eâ parte oris, quâ esculentis & poculentis iter natura patefecit.’ Cic. *de nat. deor. l. 2. c. 56. Vide quoque supra, note (b). cap. 4.*

(*d*) ‘ Multæ hujus [*quinti Paris*] nervi propagationes masticationis operi destinantur ; ideoque quoniam

each of those three parts ; as also indeed, to divers other parts of the body, which I may have occasion to mention in a more proper place (c). By which means there is all the guard that can be against pernicious food ; forasmuch as before it is taken into the stomach, it is to undergo the trial of three of the senses ; the scrutiny of the eye, the strict surveyor of its outward appearance, and the probation of the smell and taste, the two severest judges of its natural constitution and composition.

' niam alimenta ingerenda non modo gustûs, sed  
' etiam olfactûs & visûs examen subire debent, ab  
' eodem nervo, cujus rami ad palatum & fauces  
' missi, manducationis negotium peragunt, propa-  
' gines aliæ, velut exploratrices, ad nares & oculos  
' feruntur, nempe ut isthæc aliorum sensuum or-  
' gana, etiam ad objecta gustûs melius dignoscen-  
' da probationum auxiliis quibusdam instruantur,'  
Willis *Nerv. descrip. & usus*, cap. 22.

(c) See book v. chap. 8.



## C H A P. VI.

### *Of the Sense of Feeling (a).*

**H**A V I N G spent so much time upon the other senses, and therein given such ample proofs of the infinite Creator's wisdom ;  
I shall

(a) *Malpighi* is of this opinion, that as taste is performed by the *Papillæ* in the tongue, so is feeling by such like *Papillæ* under the skin. From several dissections and other observations, he thus concludes,

I shall but briefly take notice of two things relating to this last sense.

One is its organ, and nerves. For as all sensation is performed by the nerves (*b*), and indeed the other senses (performed by nerves) are

cludes, 'Ex his & similibus videbatur animus ab-  
'undè certior redditus, earundem papillarum py-  
'ramidalium copiam, quas aliàs in linguâ descrip-  
'in locis præcipuè exquisitiori tactui dicatis repe-  
'riri, eodem progigni nervoso & cuticulari corpore,  
'simulque circumvolvi reticulari involucro, & ex-  
'timam cuticulam, veluti ultimum terminum attingere.----Microscopio quilibet in manûs dorso pro-  
'sudore orificia quædam miro ordine dispersa in-  
'tueri potest, circa quæ frequentia quædam capitula  
'affurgunt; hæc verò sunt papillarum fines, dum  
'à cute affurgentes interpositum superant rete, si-  
'mulque extimam cuticulam. Hæc repetitis sec-  
'tionibus deprehendi; ex quibus non improbabili-  
'ter deducam, sicuti ex elatioribus.----papillis----  
'in linguâ, gustûs organon elicitur,----ita ex copi-  
'osâ harum papillarum congerie----in organis, ubi  
'maximè animalia tactûs môtione afficiuntur,----  
'adæquatum tactûs organum sufficienter haberi.'  
Malpig. *de extern. tact. org.* p. 26. Consul. quoque  
*eiusd. vit. ep.* 28.

These observations of *Malpighi*, our late curious and diligent *Mr. Cowper* hath confirmed, and given us very elegant cuts both of the skin, and the Papillæ, and the nerves, glands, &c. under it, from microscopical observations. *Vide Cowper's Anat. introd. and tab.* 4.

(*b*) Although the eye be the usual judge of colours, yet some have been able to distinguish them by their feeling. 'Quidam fuit qui venit ad M.

'Duc.

are a kind of feeling; so is this sense of feeling performed by nerves likewise, spread in the most incomparable, curious manner throughout the whole body. But to describe their origin in the brain, and spinal-marrow, their ramifications to all the parts, their insinuations with one another, and other matters; whereby not only the sense of feeling is performed, but also animal motion, and admirable consent and harmony of all the parts of the body is effected (To describe, I say, these things) would take up too much time, and I have already, and shall, as I go along, give some hints thereof.

The other thing I shall take notice of, is, the dispersion of this sense throughout the body, both without and within. The other senses, I have observ'd, are seated in the very best place for the relief and comfort, the guard and benefit of the animal. And forasmuch as it is necessary to the being and well-being of the body, that every part should be sensible of things safe, or things prejudicial to itself; therefore, it is an admirable contrivance of the great Creator, to disperse this sense of feeling throughout

'Duc. *Hetruriae* aulam, qui colores per tactum cognoscebat. Pro experimento velum sericum, uniformiter textum, pluribus coloribus tinctum, offerebatur, & veraciter de colore in singulis partibus judicabat.' Grimald. *de Lum. & col. prop.*

throughout every part (c) ; to distinguish between pleasure and pain ; things salutary, and things hurtful to the body.

Thus in the five senses of animals, we have an oeconomy worthy of the Creator, and manifestly demonstrating his power, wisdom, and indulgence. For whether we consider the mechanism of the organs, or the great use and convenience of each sense, we find it noble and grand, curious and artificial ; and every way worthy of its infinite Maker, and beyond the wit and power of any thing but a God : And therefore we must even deny our senses, by denying them to be God's handy-work.

And now from those chief machines of animal performances and enjoyments, the five senses, let us pass to another thing in common to all the sensitive creatures, which is respiration.

(c) ' *Tactus autem toto corpore æquabiliter fusus est, ut omnes ictus, omnesque nimios & frigoris & caloris appulsus, sentire possimus.* ' Cic. *ubi supra.*

' *Tactus sensus omnibus est, etiam quibus nullus alius ; nam & ostreis, & terrestribus vermibus quoque. Existimaverim omnibus sensum & gustatû esse. Cur enim alios alia sapes appetunt ? in quo vel præcipua naturæ architectio.* ' Plin. *nat. hist. l. 10. c. 71.*

## C H A P. VII.

## Of Respiration.

OF all the acts of animal life, this is one of the chief, and most necessary. For whatsoever hath animal life, hath also the faculty of respiration, or somewhat equivalent thereto (a). Indeed so congenial is this with life,

(a) The uses assign'd to Respiration by all the anatomists before *Malpighi*'s discoveries of the structure of the lungs, are so various, and many of them so improbable, that it would be frivolous to recount them, but the more eminent modern anatomists assign these uses. *Willis* thus sums up his opinion, 'Præcipua pulmonum functio, & usus sunt, sanguinem & aërem per totas partium compages, intimosque recessus, atque ductus quosque minutissimos traducere, & ubique invicem committere; in eum nempe finem, ut sanguis venosus à circuitu redux, & chymo recenti dilutus---tum perfectius misceatur & velut subigatur, tum potissimum ut secundum omnes suas partes ab aëre nitroso de novo accendatur.' *Pharmacent.* p. 2. §. 1. c. 2. §. 2. *Mayow* saith rightly, that one grand use of Expiration is, 'Ut cum aëre expulso, etiam vapores è sanguine exhalantes, simul exsulfentur.' And as for Inspiration, that it conveyeth a nitro-aerial ferment to the blood, to which the animal spirits are owing, and all muscular-motion. *Mayow de respir. p. 22, &c. meâ edit.*

Somewhat of the opinion of these two last cited, if I mistake not (it being long since I read their tracts,



life, that breath and life are in scripture phrase and

tracts, and have them not now at hand) were *Ent, Sylvius, Swammerden, Diemerbroek*, and my friend *Mr. Ray*, in an unpublish'd tract of his, and his letters now in my hands.

But our *Dr. Thurston*, for good reasons, rejects these from being principal uses of respiration, and thinks, with great reason, the principal uses to be, to move, or pass the blood, from the right to the left ventricle of the heart. Upon which account persons hanged, drowned, or strangled by catarrhs, so suddenly die, namely, because the circulation of their blood is stopped. For the same reason also it is, that animals die so soon in the air-pump. Among other proofs he instanceth in an experiment of *Dr. Croon*, *Proff. Gresh.* which he made before our *R. S.* by strangling a pullet, so that not the least sign of life appeared; but by blowing wind in the lungs through the *Trachea*, and so setting the lungs a playing, he brought the bird to life again. Another experiment was once tried by *Dr. Walter Needham*, before *Mr. Boyle*, and others at *Oxford*, by hanging a dog, so that the heart ceased moving. But hastily opening the dog, and blowing wind into the *Ductus Pecquetianus*, he put the blood in motion, and by that means the heart, and so recovered the dog to life again. *Vid. Thurston de respir. us. p. 60, and 63. mea edit.*

Such an experiment as *Dr. Croon's*, my friend, the late justly renowned *Dr. Hook*, shewed also our Royal Society. He cut away the *Ribs*, *Diaphragm*, and *Pericardium*, of a dog; also the top of the wind-pipe, that he might tie it on to the nose of a pair of bellows; and by blowing into the lungs, he restored the

and common speech taken as synonymous things,

the dog to life ; and then ceasing blowing, the dog would soon fall into dying fits ; but by blowing again, he recovered ; and so alternately would die, and recover, for a considerable time, as long and often as they pleased. *Phil. Transf.* No 28.

For the farther confirmation of Dr. *Thurston's* opinion, the ingenious Dr. *Musgraves* cut off, and close stopped up the windpipe of a dog with a cork, and then threw open the Thorax ; where he found the blood stagnating in the lungs, the Arteria Pulmonaris, the right Ventricle and Auricle of the heart, and the two great trunks of the Cava, distended with blood to an immense degree ; but at the same time, the Vena Pulmonaris, the left Ventricle and Auricle of the heart in a manner empty, hardly a spoonful of blood therein. *Phil. Transf.* No 240. Or both the experiments may be together met with in Lowth. *Abridg.* Vol. III. p. 66, 67.

This opinion of our learned *Thurston*, the late learned *Etmullerus* espoused, who being particular in reckoning up the uses of respiration, I shall therefore the more largely cite him. Respiration, saith he, serves, 1. Ad olfactum. 2. Ad secretum & sputationem. 3. Ad oscitationem, tussim, sternutationem, emunctionemque. 4. Ad liquidorum sorbitionem, suctionemve. 5. Ad loquelam, cantum, clamorem, risum, fletum, flatum, &c. 6. Ad fœcum alvi, urinæ, fœtus, molæve, necnon secundinarum expulsionem. 7. Ad promotionem ventriculi, intestinorum, lacteorumque vasorum, &c. contenta. 8. Ad halitus aqueos sanguinis è pulmonibus, aëris ope, exportandos. 9. Ad diapnoën. 10. Ad exactiorem chyli, lymphæque, necnon sanguinis--- miscelam.

things, or at least, necessary concomitants of  
 one

‘ lam. 11. Ad conciliandum sanguini----- cœci-  
 ‘ neam rubedinem, &c. 12. Nec morosè negabi-  
 ‘ mus aërem---pulmones, & sanguinem illos trans-  
 ‘ currentem, minùs calida reddere, &c. 15. Quòd  
 ‘ denique aër sanguini singulis respirationibus ali-  
 ‘ quantillâ sui parte, admixtus, paucissimas quas-  
 ‘ dam in spirituum animalium elaboratione parti-  
 ‘ culas simul contrîbuat.’ All these uses, although  
 of great consequence, yet he thinks rather conduce  
 to the well-being, than the being of the animal;  
 because without any of them, the animal would not  
 so speedily die, as it doth by strangling, or in the  
 air-pump. He therefore assigns a 14th, and the  
 principal use of respiration to be, ‘ For the passing  
 ‘ of the blood through the lungs, that is thrown  
 ‘ into them by the heart.’ *Etmul. Dissert. 2. chap.*  
*10. § 1. and 16.*

But the late Dr. *Drake*, with great ingenuity and  
 address (like a person so considerable for his years,  
 as he was in his time) not only established this no-  
 tion of respiration, but also carries it farther, mak-  
 ing it the true cause of the Diastole of the heart;  
 which neither *Borelli*, *Lower*, or *Cowper*, much less  
 any before those great men, have well accounted  
 for. That the heart is a muscle, is made evident  
 beyond all doubt by Dr. *Lower*. And that the mo-  
 tion of all muscles consists in constriction, is not  
 to be doubted also. By which means the Systole is  
 easily accounted for. But forasmuch as the heart  
 hath no Antagonist-muscle, the Diastole hath puz-  
 zled the greatest wits. But Dr. *Drake* with great  
 judgment, and much probability of reason, maketh  
 the weight of the incumbent atmosphere to be the  
 true Antagonist to all the muscles, which serve both

one another. *Moses (b)* expresseth animal-life by [the breath of life.] Saith he, *Gen. vii.*

21, 22.

for ordinary inspiration, and the constriction of the heart. The particulars of his opinion may be seen in his *Anatomy, l. 2. c. 7.* And in *Philos. Transf. N° 281.*

And I remember when I was at the university, my most ingenious and learned tutor Dr. *Willis*, when he read anatomy to us, was of opinion, that the lungs were blown up by the weight of the incumbent air, and represented the manner of respiration in this manner; viz. He put a bladder into a pair of bellows, turning back the neck of the bladder, and tying it fast, so that no air might enter in between the bladder and bellows. This being done, when the bellows were opened, the bladder would be blown up by the weight of the incumbent air; and when shut, the air would be thereby pressed forcibly out of the bladder, so as to blow the fire. The experiment I take notice of here, because (besides the illustration it gives to respiration) that great genius seems to have had a truer notion of this Phænomenon, than was very common then, viz. about the year 1677, or 78; as also, because I have in some authors met with the same experiment, without mention of Dr. *Willis*, whose I take it to have been.

Another use of great consideration, the already commended Dr. *Cheyne* assigns; namely, to form the elastick globules of which the blood principally consists, without which there would be a general obstruction in all the capillary arteries. *Cheyne's philosophical principles of natural religion*; or *Harris's Lex. tech. in Lungs.*

(b) *Gen. ii. 7.----vi. 17. and vii. 15.*

21, 22. 'All flesh that moveth on the earth, fowl, cattle, beast, creeping things, and man; all in whose nostrils was the breath of life in the dry land, died.' So the Psalmist, *Psal.* civ. 29. 'Thou takest away their breath, they die.' So grand an act therefore in common to all animals, may justly deserve a place in this survey of the works of God in the animal-kingdom.

And here I might launch out into an ample description of all the parts ministering to this necessary act, and shew the curious contrivance, and artificial structure of them; but a transient view shall suffice. I might begin with the outward guards, the nose and mouth; but these have been already touched upon. But the exquisite mechanism of the Larynx, its variety of muscles, its cartilages, all so exquisitely made for the purpose of respiration, and forming the voice (c), are very admirable:

And

(c) Because it would be endless to specify the curious mechanism of all the parts concurring to the formation of the voice; I shall therefore for a sample note only two things: 1. There are thirteen muscles provided for the motion of the five cartilages of the Larynx. *Gibs. Anat.* l. 2. c. 14. a sign of the careful and elaborate provision that is made for the voice. 2. It is a prodigious faculty of the Glottis, in contracting and dilating itself with such exquisiteness, as to form all notes: 'For (as the late ingenious Dr. Keil saith) supposing the greatest distance of the two sides of the Glottis, to be one  
tenth

And no less so is the tongue (*d*), which ministers to that and many other uses too.

Next

'tenth part of an inch in sounding twelve notes (to which the voice easily reaches) this line must be divided into twelve parts, each of which gives the aperture requisite for such a note, with a certain strength. But if we consider the sub-division of notes, into which the voice can run, the motion of the sides of the Glottis is still vastly nicer. For if two chords sounding exactly unisons, one be shortened one two thousandth part of its length, a just ear will perceive the disagreement, and a good voice will sound the difference, which is one hundred and ninety-sixth part of a note. But suppose the voice can divide a note into a hundred parts, it follows that the different apertures of the Glottis actually divide the tenth part of an inch into twelve hundred parts, the effect of each of which produces a sensible alteration upon a good ear. But because each side of the Glottis moves just equally, therefore the divisions are just double; or the sides of the Glottis, by their motion, do actually divide one tenth part of an inch into two thousand four hundred parts.' Keil's

*Anat. cap. 3. § 7.*

(*d*) Among the instruments of speech, the tongue is a necessary one; and so necessary, that it is generally thought no speech can be without it. But in the third Tome of the *Ephem. Germ.* is published, Jac. Rolandi Aglossostomographia, five descriptio oris sine lingua quod perfectè loquitur, & reliquas suas functiones naturaliter exercet. The person described is one *Pet. Durand*, a French Boy of eight or nine years old, who at five or six lost his tongue by a gangrene, occasion'd by the small-pox: Not-



Next, the fabrick of the (e) Trachea deserves especial remark. Its valve, the Epiglottis

withstanding which, he could (as the title saith) speak perfectly, as also taste, spit, swallow, and chew his food; but this latter he could do only on that side he put it into, not being able to turn it to the other side of his mouth.

In the same tract, *chap. 6.* is this observation of  
 ‘ ventriloquous persons; ‘ *Memini me à quodam sat*  
 ‘ *celebri anatomico audivisse, dum de duplicaturâ*  
 ‘ *mediastini ageret, si membrana ista duplex natu-*  
 ‘ *ralitèr unita in duas partes dividatur, loquelam*  
 ‘ *quasi ex pectore procedere, ut circumstantes cre-*  
 ‘ *dant dæmoniacum hunc, aut sternomythum.*’

(e) ‘ The variation of the wind-pipe is observable  
 ‘ in every creature, according as it is necessary for  
 ‘ that of the voice. In an Urchin, which hath a  
 ‘ very small voice, it is hardly more than membra-  
 ‘ nous: And in a Pidgeon, which hath a low and  
 ‘ soft note, it is partly cartilaginous, and partly  
 ‘ membranous. In an Owl, which hath a good  
 ‘ audible note, it is more cartilaginous; but that  
 ‘ of a Jay hath hard bones instead of cartilages;  
 ‘ and so of a Linnet; whereby they have both of  
 ‘ them a louder and stronger note, &c.

‘ The rings of the wind-pipe are fitted for the  
 ‘ modulation of the voice: For in Dogs and Cats,  
 ‘ which in the expression of divers passions use a  
 ‘ great many notes (as men do) they are open and  
 ‘ flexible, as in man. Whereby all, or any of  
 ‘ them, are dilated or contracted, more or less, as  
 ‘ is convenient for a higher or deeper note, &c.  
 ‘ whereas in some other animals, as in the Japan-  
 ‘ Peacock, which useth hardly more than one sin-  
 ‘ gle note, they are entire, &c.’ *Grew’s Cosmolog.*  
*Sacr, book i, chap. v. § 9, 10.*

glottis on the top, to fence against all annoyances; its cartilaginous rings (*f*) nearly environing it, with its membranous parts next the gullet, to give the freer passage to the descent of the food. And lastly, its inner tegument, of exquisite sense, to be readily affected with, and to make efforts against every thing that is hurtful or offensive: These, I say, do all justly deserve our admiration.

And no less prodigious are the parts farther within; the Bronchi, the Vesiculæ (*g*), with their

(*f*) It is a farther manifest indication of singular design in the cartilaginous rings of the Aspera Arteria, that all the way where they are contiguous to the Oesophagus, they are membranous, to afford an easy passage to the food; but after that, in the Bronchi, they are, some compleatly angular, some triangular, &c. And another observable is, the lower parts of the superior cartilages, receive the upper parts of the inferior in the Bronchi; whereas in the Aspera Arteria, the cartilages run and remain parallel to one another; which is a noble difference or mechanism in this (in a manner) one and the same part, enabling the lungs, and Bronchi, to contract themselves in expiration, and to extend and dilate themselves in inspiration.

(*g*) I shall not here intrench so much upon the anatomist's province, to give a description of the lungs, although it be a curious piece of God's workmanship; but refer to Signior *Malpighi*, the first discoverer of their Vesiculæ in 1660, in his two letters to *Borelli de Pulmon*. Also to Dr. *Willis's Pharm. rat. pag. 2. § 1. cap. 1. de Respir. orig. & us.* who.

their muscular fibres (*b*), as some assert they have, together with the arteries and veins, which

as he wrote after *Malpighi*, so hath more accurately described those parts; and to Mr. *Cowper's Anat. Tab. 24, 25*. And if the reader hath a mind to see what opposition Signior *Malpighi's* discoveries met with at home and abroad, and what controversies he had on that account; as also his censures of Dr. *Willis's* description and figures, he may consult *Malpighi's* life written by himself, p. 4 to 21.

That the lungs consist of *Vesiculæ*, or *Lobuli* of *Vesiculæ* admitting of air from the *Bronchi*, is visible, because they may be blown up, cleansed of blood, and so dried. But Mr. *Cowper* saith, he could never part the *Lobuli* (so as to make Dr. *Willis's* fig. 1. tab. 3 & 4.) so that probably the *Vesiculæ* are contiguous to one another throughout each lobe of the lungs. And not only air, but *Diembroeck* proves, that the *Vesiculæ* admit of dust also, from two asthmatick persons he opened; one a stone-cutter's man, the *Vesiculæ* of whose lungs were so stuffed with dust, that in cutting, his knife went as if through an heap of sand; the other was a feather-driver, who had these bladders filled with the fine dust or down of feathers.

(*b*) There is a considerable difference between Dr. *Willis* and *Etmuller*; viz. Whether the *Vesiculæ* of the lungs have any muscular fibres or not? *Etmuller* expressly saith, 'Nullas fibras musculosas, multo minus rubicundam musculorum compagem (sunt enim vesiculæ albidæ & fere diaphanæ) in ipsis reperiri.' *Ubi supra, cap. 6. § 2.* And afterwards, § 3. 'Pulmones esse molles flexilesque musculosis fibris cœu propriæ explicationis organis destitutos.'

which every where accompany the airy passages; for the blood to receive there its impregnations from the air.

From hence I might proceed to the commodious form of the ribs (*i*), the curious mechanism

‘destitutos.’ But Dr. *Willis* as expressly asserts, they have musculous fibres, and assigns an excellent use of them; ‘Cellulæ istæ vesiculares, ut nixus pro expiratione contractivos edant, etiam fibras, uti per microscopium planè conspiciere est, musculares obtinent.’ *Ubi supra*, § 16. . And in the next section, ‘Ut pro datâ occasione majorem aëris copiam exsufflent, aut materiam excutientem ejiciant, fibris muscularibus donatæ, sese arcitiùs contrahunt, contentaque sua penitùs exterminant. Etenim ordinariæ pectoris systolæ, quas musculorum relaxationes ex parte efficiunt, aerem forsân totum à tracheâ & bronchis, haud tamen à vesiculis, quâque vice ejiciunt: propter has (quoties opus erit) inaniendas, & totius pectoris cavitâs plurimùm angustatur, & cellulæ ipsæ vesiculares à propriis fibris constrictis coarctantur.’

(*i*) ‘Circa hos motus [scil. pectoris dilatationem, &c.] divini conditoris mechanicen, ad regulas mathematicas planè adaptatam, satis admirari non possumus: siquidem nullâ aliâ in re manifestiùs, ‘Ο Θεός γεωμετρεῖν videtur. Quippe cùm pectoris tum ampliatio, tum coarctatio à quibusdam musculis (quorum munus unicum est contrahere) perfici debeat; res ita instituitur, ut costæ quæ thoracis, velut parallelogramma oblongi versus cylindrum incurvati, latera efformant, in figuram modò quadratam, cum angulis rectis, pro pectoris ampliatiōe; modò in rhomboidem, cum angulis

chanism of the intercostal muscles (*k*), the diaphragm, and all the other muscles (*l*), ministering both to the ordinary, and extraordinary offices

‘angulis acutis pro ejusdem contractione, ducantur, &c.’ Willis *ubi supra*, § 28.

Galen having spoken of the parts ministering to respiration, concludeth, ‘Nihil usquam à naturâ illo pacto per incuriam fuisse præteritum, quæ cum omnia præsentiret & provideret, quæ sunt necessaria illa, quæ causa alicujus extiterunt, consecutura omnibus instaurationes parare occupavit, cujus apparatus copiosa facultas admirabilem sapientiam testatur.’ *De us. part. l. 3. c. 15.* See also *l. 6. c. 1.*

(*k*) For the structure of the intercostals, midriff, &c. I shall refer to Dr. Willis, and other anatomists. But Dr. Drake taxeth Dr. Willis with an error, in fancying there is an opposition in the office of the intercostals, by reason that the fibres of the external and internal intercostals decussate; that therefore the external serve to raise the ribs, the internal to draw them down. But Dr. Drake is of Steno’s, and Dr. Mayow’s opinion, That notwithstanding the decussation of their fibres, the power they exert upon, and the motion they effect in the ribs, is one and the same. Drake’s *Anat. l. 2. c. 7.* and *l. 4. c. 5.* Mayow *de respir. c. 7.*

(*l*) Although Dr. Drake, and some others, deny the intercostals being antagonist-muscles, as in the preceding note; yet they, and most other anatomists that I have met with, attribute a considerable power to them in the act of respiration, as they do also to the subclavian and triangular-muscles; but the learned Etmüller denies it for these three reasons,

‘1. Quia

offices of respiration. But passing them by, I shall stop at one prodigious work of nature, and manifest contrivance of the Almighty Creator, which although taken notice of by others (*m*), yet cannot be easily passed by in the subject I am upon; and that is, the circulation

1. Quia respirando nullam in illis contractionem sentio. 2. Quia---- sibi invicem non adducuntur, &c. 3. Quia costæ omnes ab aliis modò enarratis musculis moventur, idque simul, &c. Intercoastales itaque, necnon subclavios musculos costis, parietum instar, ad complenda interstitia intercoastalia pectusque integrandum, ac costas connectendas, interjectos esse, probabiliter concludo; quo munere triangulares etiam----fungi, rationi consentaneum est. *Etmul. Dissert. 2. cap. 4. § 6.*

But as to the use of the Triangular Muscle in respiration, we may judge of it, from its remarkable size and use in a dog; of which Dr. *Willis* gives this account from *Fallopins*: 'In homine parvus adeò & subtilis iste [*musculus*] est, ut vix pro musculo accipi queat: in cane per totum os pectoris protenditur, & cartilagine omnes, etiam verarum costarum sterni inosculatas, occupat: Cujus discriminis ratio divinam circa animalium fabricas providentiam planè indigitat. Quippe cùm hoc animal, ad cursus velocissimos & diu continuandos natum, quo sanguis, dum intensius agitur, ritè accendatur eventileturque, aërem celeritè & fortiter uti inspirare debet----idcirco propter hunc actum firmiùs obeundum (cujus in homine haud magnus est usus) musculus caninus molem ingentem & tanto operi parem sortitur.' *Willis ubi supra, § 32.*

(*m*) Ray's *Wisdom of God in the Creation*. Page 343.



tion of the blood in the Foetus in the womb, is different from the method thereof after it is born. In the womb, whilst it is as one body with the mother, and there is no occasion, nor place for respiration, there are two passages (\*) on purpose for the transmission of the blood,

(\*) Mr. *Cbeselden*, an ingenious and most accurate anatomist, having somewhat particular in his observations about the circulation of the blood through the heart of the Foetus, I shall present the reader with some of his observations, which he favoured me with the sight of. 'The blood (saith he) which is brought to the heart by the ascending Cava, passes out of the right auricle into the left, through a passage called *Foramen Ovale*, in the Septum [common to them both] without passing through the right ventricle (as after the birth) while the blood from the descending Cava passeth through the right auricle and ventricle into the pulmonary artery, and thence into the Aorta through the duct, betwixt that and the pulmonary artery, called *Ductus Arteriosus*, whilst a small portion of the blood, thrown into the pulmonary artery, passeth through the lungs, no more than is sufficient to keep open the pulmonary vessels. Thus both ventricles are employed driving the blood thro' the Aorta to all parts of the Foetus, and to the mother too. But after the birth, the blood being to be driven from the Aorta thro' the Foetus alone, and not the mother too, one ventricle becomes sufficient, whilst the other is employed in driving the blood thro' the lungs, the *Ductus arteriosus* being shut up by means of the alteration of its position, which happens to it from

blood, without passing it through the lungs. But as soon as the Fœtus is born, and become thereby a perfectly distinct being, and breathes for itself, then these two passages are shut up; one nearly obliterated, the other becomes only a ligament, except in some creatures that are amphibious, or are forced to lie long under water, in whom these passages probably remain open (o). And

‘ from the raising of the Aorta by the lungs, when  
‘ they become inflated. After that the blood is  
‘ thus driven into the lungs, in its return it shuts  
‘ the Valve of the Foramen Ovale against the  
‘ Foramen itself, to whose sides it soon adheres,  
‘ and so stops up the passage. The Ductus Arteriosus, or Ductus Arteriosus in ligamentum versus,  
‘ is seldom to be discerned in adult bodies, but the  
‘ figure of the Foramen Ovale is never obliterated.’

(o) It hath been generally thought to be not improbable, but that on some occasions the Foramen Ovale may remain open in man. In a girl of four or five years of age, Dr. Connor found it but half closed, and in the form of a crescent. And he thinks somewhat of this kind might be in the person whose skeleton was found to have no joints in the back-bone, ribs, &c. Of which a description, with cuts, may be found in *Phil. Transf.* No. 215. And more largely in his *Dissert. med. phys. de suspensio ossium coalitu*, where he adds to the girl, in whom the For. Ov. was not shut, a like observation of another girl he opened at *Oxford* of three years old; ‘ in quâ Foramen Ovale ferè erat occlusum, in medio tamen, exili foramine, per quod turundam  
‘ faciliè transmissi, erat pervium,’ p. 30. So Mr. Cowper (than whom none more accurate and better

And now what action of any rational creature, what is there in a man's life, that doth more plainly shew design, reason, and contrivance,

judge) saith, 'I have often found the Foramen Ovale open in the adult.' *Anat. append. fig. 3.* But Mr. *Cbeselden* is of a different opinion, of which in the following note.

From somewhat of this cause, I am apt to think it was that the *Tronningholm* gardiner escaped drowning, and some others mentioned by *Pecblin*. His stories are, 'Hortulanus Tronningholmenfis etiam num vivens, annos natus 65 pro illâ ætate satis adhuc valens & vegetus, cùm ante 18 annos, aliù in aquas delapso opem ferre vellet, forte fortunâ & ipse per glaciem incautiùs procedens, aquas incidit 18 ulnas profundas: ubi ille, corpore erecto quasi ad perpendiculum, pedibus fundo adhæsit. Constitit sic per 16 horas, antequam produceretur in auras. Dixit autem, simul ac infra aquarum superficiem fuit demersus, statim obriguisset totum, & si quem tum habuit motum & sensum, amisisset, nisi quod sonantes Stockholmii campanas etiam sub aquis obscuriùs percipere sibi sit visus. Sensit etiam, statim sese velut vesiculam ori applicasse, adeò ut aqua nulla os penetraverit, in aures verò transitum, etiam sentiente illo, haberet; atque inde auditum suum debilitatum aliquandiu esse. Hoc statu dum 16 horas permansit frustra quæsitus, tandem repertum, conto in caput infixò, cujus etiam sensum se habuisse dixit, fundo extraxerunt, sperantes ex more aut persuasione gentis revicturum esse. Itaque pannis linteisque productum obvolvunt, ne aër admitti possit perniciosus futurus subito illapsu; custoditum

fic

vance, than this very act of nature doth the contrivance and design of the great God of nature? What is thought and contrivance, if this be not? namely, that there should be a temporary

fic satis ab aëre sensim sensimque tepidiori loco admovent, mox calidis adoriuntur fasciis, fricant, radunt, & sufflaminatum tot horis sanguinis corporisque motum negotiosâ illâ operâ reducant: denique antapoplecticis & genialibus liquoribus vitæ reddunt & pristinæ mobilitati. Retulit is atque ostendit se etiamnum in capite circumferre vestigia violentiæ à conto illatæ, & cephalalgis vexari gravissimis. Et propter hunc ipsum casum, religiosè à popularibus, & hujusce rei testibus probatum, Serenissimæ Reginæ matris munificentia & annuo stipendio est donatus----& serenif. Principi-----oblatus vivus sui testis-----consignatam manu habes historiam D. Tilasii Biblioth. Reg. Præfecti, qui testatus est se prænovisse mulierem, quæ tres ipsos dies sub aquis hæsit, & similem in modum, quo hortulanus ille, resuscitata, adhuc dum lucis plenâ fruitur usurâ. Accedit Nob. Burmanni----fides, qui confessus est,----se in pago Bonefs parochiæ Pithoviæ concionem frequentasse funebrem, in quâ dum acta recenseret præco senis cujusdam septuagenarii Laur. Jonæ-----audiverit ex ore concionatoris, vivum eum, adolescentem 17 annorum aquis subversum, 7 demum hebdomadâ (rem prodigiosam!) extractum ad se rediisse vivum & incolumem. Pechlin. *de Aer. & Alim. def. c. 10.*

Shall we to this cause, or to the ossification, or more than ordinary strength of the wind-pipe attribute the recovery to life of persons hanged? Of

temporary part in the body, made just for the present exigence ; to continue whilst there is occasion for it, and to cease when there is none ; in some creatures to remain always, by reason of their amphibious way of living, and in land-animals (purely such) to cease.

Another excellent contrivance, a-kin to the last, is, for the preservation of such creatures  
whose

which *Pecblin* gives an instance that fell under his own knowledge, of a woman hanged, and in all appearance dead, but recovered by a physician accidentally coming in, with a plentiful administration of Spir. Sal. Armon. *Pech. ib. c. 7.* And the story of *Anne Green*, executed at *Oxford*, Dec. 14. 1650. is still well remember'd among the seniors there. ' She was hanged by the neck near half an hour, some of her friends in the mean time ' thumping her on the breast, others hanging with ' all their weight upon her legs, sometimes lifting ' her up, and then pulling her down again with a ' sudden jirk, thereby the sooner to dispatch her ' out of her pain ; ' as her printed account wordeth it. After she was in her coffin, being observed to breathe, a lusty fellow stamped with all his force on her breast and stomach, to put her out of her pain. But by the assistance of Dr. *Peity*, Dr. *Willis*, Dr. *Batburst*, and Dr. *Clark*, she was again brought to life. I myself saw her many years after, after that she had (I heard) born divers children. The particulars of her crime, execution, and restauration, see in a little pamphlet called *News from the dead*, written, as I have been informed, by Dr. *Batburst* (afterwards the most vigilant and learned president of *Trinity-College, Oxon*) and published in 1651, with verses upon the occasion.

whose occasions frequently necessitate them to live without, or with but little respiration: Fishes might be named here, whose habitation is always in the waters; but these belong to an element which I cannot at present engage in. But there are many animals of our own element, or partly so, whose organs of respiration, whose blood, whose heart, and other instruments of life, are admirably accommodated to their method of living: Thus many amphibious creatures (*p*), who live in water as well

(*p*) The Sea-Calf hath the Foramen Ovale, by which means it is enabled to stay long under water, as the *Paris Anatomists*. Of which see in *book vi. chap. 5. note (c)*.

But the fore-mentioned Mr. *Cbesfelden*, thinks the Foramen Ovale is neither open in amphibious creatures, nor any adult land-animals. 'When I first (saith he) applied myself to the dissection of human bodies, I had no distrust of the frequent accounts of the Foramen Ovale being open in adults; but I find since, that I mistook the Ostium Venerum Coronariarum for the Foramen. The like I suppose authors have done, who assert that it is always open in amphibious animals; for we have made diligent enquiry into those animals, and never found it open. Neither would that (as they imagine) serve these creatures to live under water, as the Foetus doth in Utero, unless the Ductus Arteriosus was open also.'

This opinion of Mr. *Cbesfelden* hath this to render it probable, That the Ostium Venerum Coronariarum is so near the Foramen Ovale, that without



well as air ; many quadrupeds, birds, insects, and other animals, who can live some hours, days, yea, whole winters, with little or no respiration, in a torpitude, or sort of sleep, or middle state between life and death : The provision made for these peculiar occasions of life, in the fabrick of the lungs, the heart, and other parts of such creatures (*q*), is manifestly the work of him, who, as *St. Paul* saith (*r*), ‘ Giveth to all breath and life, and all things.’

due regard, it may be easily mistaken for it. Such therefore as have opportunity of examining this part in amphibious animals, or any other subject, ought to seek for the Ostium, whenever they suspect they have met with the Foramen.

(*q*) Of the singular conformation of the heart and lungs of the Tortoise, which is an amphibious animal, see *book vi. chap. 5. note (b)*.

(*r*) *Acts xvii. 25.*



## C H A P. VIII.

### *Of the Motion of Animals.*

**N**E X T to the two grand acts of animal life, their sense and respiration, I shall consider their Motion, or Locomotive faculty, whereby they convey themselves from place to place, according to their occasions, and way of life : And the admirable apparatus to this purpose, is a plain demonstration of God's particular foresight, care and especial providence towards all the animal world.

And

And here I might view, in the first place, the muscles, their curious structure (a), the nice tacking them to every joint, to pull it this way, and that way, and the other way, according to the special purpose, design, and office of every such joint: Also their various size and strength; some large and corpulent, others less, and some scarce visible to the naked eye; all exactly fitted to every place, and every use of the body. And lastly, I might take notice of the muscular motions, both involuntary and spontaneous (b).

Next,

(a) That the muscles are compounded of fibres, is visible enough. Which fibres, the curious and ingenious *Borelli* saith, are cylindraceous; not hollow, but filled with a spongy, pithy substance, after the manner of elder, as he discovered by his microscopes. *Borel. de mot. animal. part. I.*

These fibres, he saith, are naturally white; but derive their redness only from the blood in them.

These fibres do in every muscle (in the belly at least of the muscle) run parallel to one another, in a neat orderly form. But they do not all tend the same way, but some run aslant, some long ways, &c. according to the action or position of each respective muscle. The particulars of which, and of divers other observables in the muscles, would, besides figures, take up too much room in these notes; and therefore I must refer to the anatomists, particularly *Steno*, *Borelli*, *Cowper*, &c.

(b) The infinite Creator hath generally exerted his art and care, in the provision made by proper muscles and nerves for all the different motions in animal

Next, I might survey the special fabrick of the bones (c), ministring to animal motion.

Next,

animal bodies, both involuntary, and voluntary. It is a noble providence, that most of the vital motions, such as of the heart, stomach, guts, &c. are involuntary, the muscles acting whether we sleep or wake, whether we will or no. And it is no less providential that some, even of the vital motions, are partly voluntary, partly involuntary, as that, for instance, of breathing, which is performed both sleeping and waking: but can be intermitted for a short time on occasion, as for accurate hearing any thing, &c. or can be increased by a stronger blast, to make the greater discharges of the blood from the lungs, when that any thing overcharges them. And as for the other motions of the body, as of the limbs, and such as are voluntary, it is no less providence, that they are absolutely under the power of the will; so as that the animal hath it in his power to command the muscles and spirits, or any part of its body, to perform such motions and actions as it hath occasion for.

(c) 'Quid dicam de ossibus? quæ subjecta corpori mirabiles commissuras habent, & ad stabilitatem aptas, & ad artus finiendos accommodatas, & ad motum, & ad omnem corporis actionem.' Cic. *de nat. deor.* l. 2. c. 55.

By reason it would be endless to mention all the curiosities observable in the bones, I shall, for a sample, single out only an instance or two, to manifest that design was used in the structure of these parts in man.

The first shall be in the Back-bone, which (among many others) hath these two things remarkable.

I. Its

1. Its different articulations from the other joints of the body. For here most of the joints are flat, and withal guarded with asperities and hollows, made for catching and holding; so as firmly to lock and keep the joints from luxations, but withal to afford them such a motion, as is necessary for the incurvations of the body. 2. The difference of its own joints in the neck, back, and loins. In the neck, the Atlas, or upper vertebra, as also the Dentata, are curiously made, and jointed (differently from the rest) for the commodious and easy bending and turning the head every way. In the Thorax, or back, the joints are more close and firm; and in the loins, more lax and pliant; as also the spines are different, and the knobs and sockets turned the quite contrary way, to answer the occasions the body hath to bend more there, than higher in the back. I shall close this remark with the late ingenious Dr. Keil's observation.

'The structure of the Spine is the very best that can be contrived; for had it been all bone, we could have had no motion in our backs; had it been of two or three bones articulated for motion, the Medulla Spinalis must have been necessarily bruised at every angle or joint; besides, the whole would not have been so pliable for the several postures we have occasion to put ourselves in. If it had been made of several bones, without intervening cartilages, we should have had no more use of it, than if it had been but one bone. If each Vertebra had had its own distinct cartilages, it might have been easily dislocated. And lastly, the oblique processes of each superior and inferior Vertebra keep the middle one, that it can neither be thrust backwards nor forwards to compress the Medulla Spinalis.' Keil's anat. cap. 5. § 8.

Compare

Next, I might take notice of the joints (d), their compleat form adjusted to the place, and office

Compare here what *Galen* saith of the articulations, ligaments, perforation, &c. of the Spine, to prove the wisdom and providence of the maker of animal bodies, against such as found fault with nature's works; among which he names *Diagoras*, *Anaxagoras*, *Asclepiades*, and *Epicurus*. *Vid. Galen. de us. part. l. 12. init. and chap. 11, &c. also l. 13. init.*

2. The next instance shall be in one or two things, wherein the skeletons of sexes differ. Thus the Pelvis made in the belly by the Ilium, Ossa Coxendicis and Pubis, is larger in a female than male skeleton, that there may be more room for the lying of the Viscera and Foetus. So the cartilage bracing together the two Ossa Pubis, or Sharebones, *Bartholine* saith, is twice thicker and laxer in women than men: As also is the cartilage that tieth the Os Sacrum to its Vertebra; and all to give way to the passage of the Foetus.

Another considerable difference is in the cartilaginous production of the seven long ribs, whereby they are braced to the breast-bone. These are harder and firmer in women than in men; the better to support the weight of the breasts, the sucking infant, &c.

(d) It is remarkable in the joints, and a manifest act of caution and design: 1. That altho' the motion of the limbs be circular, yet the center of that motion is not in a point, but an ample superficies. In a point, the bones would wear and penetrate one another; the joints would be exceedingly weak, &c. but the joints consisting of two large super-

office they are employed in ; their bandage, keeping them from luxations ; the oily matter

superficies, concave, and convex, some furrowed and ridged, some like a ball and socket, and all lubricated with an oily substance, they are incomparably prepared both for motion and strength. 2. That the bones next the joint are not spungy, as their extremities commonly are, nor hard and brittle, but capped with a strong, tough, smooth, cartilaginous substance, serving both to strength and motion.

But let us here take notice of what *Galen* mentions on this subject. ' *Articulorum unusquisque eminentiam cavitati immissam habet : Veruntamen hoc fortasse non adeò mirabile est : Sed si, considerata omnium totius corporis ossium mutuâ connexionione, eminentias cavitatibus suscipientibus æquales semper inveneris, hoc mirabile. Si enim justo amplior esset cavitas, lusus sanè & infirmus fieret articulus ; si strictior, motus difficulter fieret, ut qui nullam versionem haberet ; ac periculum esset non parvum, eminentias ossium arctatas frangi : sed horum neutrum factum est.-----* Sed quoniam ex tam securâ constructione periculum erat, ne motiones difficiliùs fierent, & eminentiæ ossium extererentur, duplex rursus auxiliium in id natura molita est. 1. Cartilagine os utrumque subjungens, atque obtinens : alterum, ipsis cartilaginibus humorem unctuosum, velut oleum, superfundens ; per quem facilè mobilis, & attritu contumax omnis articulatio ossium facta est.----- Ut undique diligenter articulus omnis custodiretur, ligamenta quædam ex utroque esse produxit natura.' *Galen de us. part. l. 1. c. 15.*



ter (e) to lubricate them, and their own smoothness to facilitate their motion.

And lastly, I might trace the various nerves throughout the body, sent about to minister to its various motions (f). I might consider their

(e) For the affording this oily or mucilaginous matter, there are Glandules very commodiously placed near the joints, so as not to suffer too great compression by the motion of the neighbouring bones, and yet to receive a due pressure, so as to cause a sufficient emission of the mucilage into the joints. Also, another thing considerable is, that the excretory ducts of the Mucilaginous Glands have some length in their passage from the glands to their mouths; which is a good contrivance, to prevent their mouths being oppressed by the mucilage, as also to hinder the too plentiful effusion thereof, but yet to afford a due expresseure of it at all times, and on all occasions, as particularly in violent and long-continued motions of the joints, when there is a greater than ordinary expence of it. See *Cowper's Anat. Tab. 79.*

(f) There is no doubt to be made, but that the muscles receive their motion from the nerves. For if a nerve be cut, or streightly bound, that goes to any muscle, that muscle shall immediately lose its motion. Which is doubtless the case of paralyticks; whose nerves are some of them by obstructions, or such like means, reduced to the same state as if cut or bound.

And this also is the cause of that numbness or sleepiness we find oftentimes, by long sitting or lying on any part.

Neither

their origin (*g*), their ramifications to the several parts, and their inosculation with one another, according to the harmony and accord of one part with another, necessary for the benefit of the animal. But some of these things I have given some touches upon already, and more I shall mention hereafter (*b*), and it would be tedious here to insist upon them all.

I shall therefore only speak distinctly to the locomotive act itself, or what directly relates to it.

And here it is admirable to consider the various methods of nature (*i*), suited to the occasions

Neither is this a modern notion only; for *Galen* saith, 'Principium nervorum omnium cerebrum est, & spinalis medulla.---- Et nervi à cerebro animalem virtutem accipiunt-----nervorum utilitas est facultatem sensûs & motûs à principio in partes diducere.' And this he intimates to have been the opinion of *Hippocrates* and *Plato*, *de us. part. l. 1. c. 16. & passim.*

(*g*) *Dr. Willis* thinks, that in the brain the spirits are elaborated that minister to voluntary motion; but in the Cerebellum, such as affect involuntary, or natural motions; such as that of the hearts, the lungs, &c. *Cerebri Anat. c. 15.*

(*b*) See *book v. chap. 3.*

(*i*) To the foregoing, I shall briefly add some examples of the special provision made for the motion of some animals by temporary parts. Frogs and Toads, in their Tad-pole state, have tails, which fall off when their legs are grown out. The *La-*

occasions of various animals. In some their motion is swift, in others flow ; in some performed with two, four, or more legs ; in some with two, or four wings ; in some with neither (*k*).

And first for swift or slow motions. This we find is proportional to the occasions of each respective animal. Reptiles, whose food, habitation, and nests, lie in the next clod, plant, tree, or hole, or can bear long hunger and hardship, they need neither legs nor wings for their transportation ; but their vermicular or sinuous motion (performed with no less art, and

certa Aquatica, or Water-Newt, when young, hath four neat ramified fins, two on a side, growing out a little above its fore-legs, to poise and keep its body upright (which gives it the resemblance of a young fish) which fall off when the legs are grown. And the Nymphæ and Aureliæ, of all or most of the insects bred in the waters, as they have particular forms, different from the insects they produce ; so have also peculiar parts afforded them for their motions in the waters ; oars, tails, and every part adapted to the waters, which are utterly varied in the insects themselves, in their mature state in the air.

(*k*) ‘ Jam verò alia animalia gradiendo, alia serpendo, ad pastum accedunt, alia volando, alia nando.’ Cic. *de nat. deor.* l. 2. c. 47.

Compare also what *Galen* excellently observes concerning the number of feet in man, and in other animals ; and the wise provision thereby made for the use and benefit of the respective animals. *De us. part.* in the beginning of the third book,

and as curiously provided for as the legs or wings of other creatures: This, I say) is sufficient for their conveyance.

Man and beasts, whose occasions require a large room, have accordingly a swifter motion, with proper engines for that service; answerable to their range for food, their occupation of business, or their want of armature, and to secure them against harms (*l*).

But for the winged creatures (birds and insects) as they are to traverse large tracts of land and water for their food, for their commodious habitation, or breeding their young, to find places of retreat and security from mischiefs; so they have accordingly the faculty of flying in the air, and that swiftly or slowly, a long or a short time, according to their occasions and way of life. And accordingly their wings, and whole body, are curiously prepared for such a motion; as I intend to shew in a proper place (*m*). Another

(*l*) As I shall hereafter shew, that the indulgent Creator hath abundantly provided for the safety of animals by their cloathing, habitations, sagacity, and instruments of defence; so there appears to be a contemperament of their motion with these provisions. They that are well armed and guarded, have commonly a slower motion; whereas they that are destitute thereof, are swifter. So also timid helpless animals are commonly swift; thus Deer and Hares; but animals endowed with courage, craft, arms, &c. commonly have a slower motion,

(*m*) See book vii. chap. 1.

Another remarkable thing in the motive faculty of all creatures, is the neat, geometrical performance of it. The most accurate mathematician, the most skilful in mechanick motions, cannot prescribe a nicer motion (than what they perform) to the legs and wings of those that walk or fly (*n*), or to the bodies of those that creep (*o*). Neither can the body be more compleatly poised for the motion it is to have in every creature, than it already actually is. From the largest elephant to the smallest mite, we find the body artfully balanced (*p*). The head not too heavy, nor too light for the rest of the body, nor the rest of the body for it (*q*). The Viscera are not let loose, or so placed, as to swag,

(*n*) See *book vii. chap. 1. the end.*

(*o*) See *book ix. chap. 1. note (c).*

(*p*) ‘ Siquis unquam alius opifex, æqualitatis & proportionis magnam habuit providentiam, certè natura habuit in animalium corporibus conformandis; unde Hippocrates eam rectissimè justam nominat.’ Galen. *de us. part. l. 2. c. 26.*

(*q*) The make of the bodies of some water-fowl, seems to contradict what I here say, the heads and long necks of some, as of swans, ducks, and geese; and the hinder parts of others, as of the Doucker and Moor-hen, and some other kinds, seeming to be too heavy for the rest of their body. But instead of being an argument against, it is a notable instance of, the divine art and providence, these things being nice accommodations to their way of life. Of such as have long necks, see *book vii, chap. 2. note (i).*

swag, overbalance, or over-set the body ; but well-braced, and distributed to maintain the æquipoise of the body: The motive parts also are admirably well fixed in respect to the center of gravity ; placed in the very point, fittest to support and convey the body. Every leg beareth his true share of the body's weight. And the wings so nicely are set to the center of gravity, as even in that fluid medium, the air, the body is as truly balanced, as we could have balanced it with the nicest scales.

But among all creatures, none more elegant than the sizing the body of man, the gauging his body so nicely, as to be able to stand erect, to stoop, to sit, and indeed to move any way, only with the help of so small a stay as the feet (*r*) : whose mechanism of bones, tendons, and muscles, to this purpose, is very curious and admirable.

And for such whose hinder parts seem to overbalance their foremost parts, whereby they fly with their bodies in a manner erect, this also is an excellent accommodation to their way of life, which is diving rather than flying. *Vide book vii. chap. 4. note (k).*

(*r*) See *book v. chap. 2. note (b).*



## C H A P. IX.

*Of the Place allotted to the several Tribes  
of Animals.*

**H**AVING dispatched the motion of animals, let us in the next place consider the place which the infinitely wise Creator hath appointed them to move and act, and perform the offices of the creation in. And here we find every particular well ordered. All parts of our terraqueous globe fit for an animal to live and act in, are sufficiently stocked with proper inhabitants: The watery element (unfit, one would think, for respiration and life) abounding with creatures fitted for it; its bowels abundantly stored, and its surface well bespread. The earth also is plentifully stocked in all its parts, where animals can be of any use; not probably the deepest bowels thereof indeed, being parts in all likelihood unfit for habitation and action, and where a living creature would be useless in the world; but the surface every where abundantly stored.

But that which is most considerable in this matter, and plainly sheweth the divine management in the case, is, that those creatures are manifestly designed for the place in which they are, and the use and services they perform therein. If all the animals of our globe  
had

had been made by chance, or placed by chance, or without the divine providence, their organs would have been otherwise than they are, and their place and residence confused and jumbled. Their organs (for instance) of respiration, of vision, and of motion, would have fitted any medium, or have needed none; their stomachs would have served any food, and their blood, and covering of their bodies been made for any clime, or only one clime. Consequently all the animal world would have been in a confused, inconvenient, and disorderly commixture. One animal would have wanted food, another habitation, and most of them safety. They would have all flocked to one, or a few places, taken up their rest in the temperate zones only, and coveted one food, the easiest to come at, and most specious in shew; and so would have poisoned, starved, or greatly incommoded one another. But as the matter is now ordered, the globe is equally bespread; so that no place wanteth proper inhabitants, nor any creature is destitute of a proper place, and all things necessary to its life, health, and pleasure. As the surface of the terraqueous globe is covered with different soils, with hills and vales, with seas, rivers, lakes, and ponds, with divers trees and plants, in the several places; so all these have their animal inhabitants, whose organs of life and action are manifestly adapted to such and such places and things; whose food and physick,

sick, and every other convenience of life, is to be met with at that very place appointed it. The watery, the amphibious (*a*), the airy inhabitants, and those on the dry land surface, and the subterraneous under it, they all live, and act with pleasure; they are gay, and flourish in their proper element and allotted place; they want neither for food, cloathing, or retreat; which would dwindle and die, destroy, or poison one another, if all coveted the same element, place, or food.

Nay, and as the matter is admirably well ordered, yet considering the world's increase, there would not be sufficient room, food, and other necessaries for all the living creatures, without another grand act of the divine wisdom and providence, which is, the balancing the number of individuals of each species of creatures, in that place appointed thereto: Of which in the next chapter.

(*a*) ' Est etiam admiratio nonnulla in bestiis a-  
' quatilibus iis, quæ gignuntur in terrâ: veluti  
' Crocodili, fluviatileque testudines, quædamque  
' serpentes ortæ extra aquam, simul ac primùm  
' niti possunt, aquam persequuntur. Quin etiam  
' Anatum ova Gallinis sæpe supponimus-----  
' [Pulli] deinde eas [matres] relinquunt----- &  
' effugiunt, cùm primùm aquam, quasi naturalem  
' domum, videre potuerunt.' Cic. *de nat. deer.*  
*l. 2. c. 48.*

CHAP. X.

*Of the Balance of Animals, or the due Proportion in which the world is stocked with them.*

THE whole surface of our globe can afford room and support only to such a number of all sorts of creatures; and if by their doubling, trebling, or any other multiplication of their kind, they should increase to double or treble that number, they must starve, or devour one another. The keeping therefore the balance even, is manifestly a work of the divine wisdom and providence. To which end, the great author of life hath determined the life of all creatures to such a length, and their increase to such a number, proportional to their use in the world. The life of some creatures is long, and their increase but small, and by that means they do not over-stock the world. And the same benefit is effected, where the increase is great, by the brevity of such creatures lives, by their great use, and the frequent occasions there are of them for food to man, or other animals. It is a very remarkable act of the divine providence, that useful creatures are produced in great plenty (a), and others in less. The prodigious

(a) 'Benigna circa hoc natura, innocua & escu-  
'lenta animalia foecunda generavit.' Plin. nat.  
Hist. l. 8. c. 55.

digious and frequent increase of insects, both in and out of the waters, may exemplify the one; and 'tis observable in the other, that creatures less useful, or by their voracity pernicious, have commonly fewer young, or do seldomer bring forth: Of which many instances may be given in the voracious beasts and birds. But there is one so peculiar an animal, as if made for a particular instance in our present case, and that is the Cuntur of Peru (*b*): a fowl of that magnitude, strength and

(*b*) Captain *J. Strong* gave me this account together with a quill-feather of the Cuntur [or Condor] of Peru. 'On the coast of *Cbili*, they met ' with this bird in about  $33^{\circ}$  S. Lat. not far from ' *Mocba*, an island in the South-sea---- They shot ' it sitting on a cliff, by the sea-side; that it was ' 16 feet from wing to wing extended; that the ' Spanish inhabitants told them they were afraid of ' these birds, lest they should prey upon their children. And the feather he gave me (saith the ' doctor) is 2 feet 4 inches long; the quill-part 5 ' inches three quarters long, and 1 inch and half ' about in the largest part. It weighed 3 drams, ' 27 grains and half, and is of a dark-brown colour.' *Dr. Sloane in Philos. Trans. N<sup>o</sup> 208.*

To this account, the Doctor (in a letter to Mr. *Ray*, March 31, 1694, with other papers of Mr. *Ray's* in my hands) adds the testimony of *Jos. Acosta*, l. 4. c. 7. and *Garfilas de la Vega*, who, l. 8. c. 19. saith, 'There are other fowls called ' Cuntur, and by the Spaniards corruptly Condor. Many of these fowls having been killed ' by the Spaniards, had their proportion taken, and ' from

and appetite, as to seize not only on the sheep, and lesser cattle, but even the larger beasts, yea the very children too. Now these, as they are the most pernicious of birds, so are they the most rare, being seldom seen, or only one, or a few in large countries ; enough to keep up the species, but not to over-charge the world.

Thus the balance of the animal world, is, throughout all ages, kept even ; and by a curious harmony, and just proportion between the increase of all animals, and the length of their lives, the world is through all ages well, but not over-stored : ‘ One generation passeth away, and another generation cometh (c),  
fo

‘ from end to end of their wings measured 15 or  
‘ 16 feet.----- Nature, to temper and allay their  
‘ fierceness, denied them the talons which are  
‘ given to the Eagle ; their feet being tipped with  
‘ claws, like a hen : However, their beak is strong  
‘ enough to tear off the hide, and rip up the bowels  
‘ of an Ox. Two of them will attempt a Cow or  
‘ Bull, and devour him : And it hath often hap-  
‘ pened, that one of them alone hath assaulted boys  
‘ of ten or twelve years of age, and eaten them.  
‘ Their colour is black and white, like a Magpie.  
‘ It is well there are but few of them ; for if there  
‘ were many, they would very much destroy the  
‘ cattle. They have on the fore part of their head,  
‘ a comb, not pointed like that of a Cock ; but ra-  
‘ ther even, in the form of a razor. When they  
‘ come to alight from the air, they make such a  
‘ humming noise with the fluttering of their wings,  
‘ as is enough to astonish, or make a man deaf,

(c) Eccles. i. 4,



so equally in its room, to balance the stock of the terraqueous globe in all ages and places, and among all creatures, that it is an actual demonstration of our saviour's assertion, *Matth. x. 29.* that the most inconsiderable, common creature, 'Even a Sparrow (two of which are sold for a farthing) doth not fall on the ground without our heavenly father.'

This providence of God is remarkable in every species of living creatures: But that especial management of the recruits and decays of mankind, so equally all the world over, deserves our special observation. In the beginning of the world, and so after Noah's flood, the longevity of men, as it was of absolute necessity to the more speedy peopling of the new world; so is a special instance of the divine providence in this matter (*d*). And the same

(*d*) The divine providence doth not only appear in the longevity of men immediately after the creation and flood, but also in their different longevity at those two times: immediately after the creation, when the world was to be peopled by one man, and one woman, the age of the greatest part of those on record, was 900 years and upwards: but after the flood, when there were three persons by whom the world was to be peopled, none of those patriarchs, except *Schem*, arrived to the age of 500; and only the three first of *Schem's* line; viz. *Arpbaxad*, *Salab*, and *Eber*, came near that age; which was in the first century after the flood. But in the second century we do not find any reached the age of 240. And in the third century (about the latter end of which

same providence appears in the following ages; when the world was pretty well peopled, in reducing the common age of man then to 120 years (*Gen. vi 3.*) in proportion to the occasions of the world at that time. And lastly, when the world was fully peopled after the flood (as it was in the age of Moses, and so down to our present time) the lessening the common age of man to 70 or 80 years (e) (the

which *Abraham* was born) none, except *Terab*, arrived to 200 years: by which time the world was so well peopled (that part of it, at least, where *Abraham* dwelt) that they had built cities, and began to be cantoned into distinct nations and societies, under their respective kings; so that they were able to wage war, four kings against five, *Gen. xiv.* Nay, if the accounts of *Anian*, *Berosus*, *Manetho*, and others; yea, *Africanus*, be to be credited; the world was so well peopled; even before the times we speak of, as to afford sufficient numbers for the great kingdoms of *Assyria*, *Egypt*, *Persia*, &c. But learned men generally, with great reason, reject these as legendary accounts.

If the reader hath a mind to see a computation of the increase of mankind, in the three first centuries after the flood, he may find two different ones, of the most learned archbishop *Usher*, and *Petavius*; together with a refutation of the so early beginning of the Assyrian Monarchy; as also reasons for placing *Abraham* near a thousand years after the flood; in our most learned bishop *Stillingfleet's Orig. Sac.* book iii. chap. 4. § 9.

(e) That the common age of man hath been the same in all ages since the world was peopled, is manifest from prophane, as well as sacred history. To pass

(the age mentioned by Moses, *Psal.* xc. 10. This, I say) is manifestly an appointment of the same infinite Lord that ruleth the world ; For, by this means, the peopled world is kept at a convenient stay ; neither too full, nor too empty.

by others : *Plato* lived to the age of 81, and was accounted an old man. And those which *Pliny* reckons up, *l.* 7. *c.* 48, as rare examples of long life, may, for the most part, be matched by our modern histories : especially such as *Pliny* himself gave credit unto, *Dr. Plot* hath given us divers instances in his history of *Oxfordshire*, *c.* 2. § 3. and *c.* 8. § 54. and history of *Staffordshire*, *c.* 8. § 91, &c. Among others, one is of twelve tenants of *Mr. Biddulph's*, that together made 1000 years of age. But the most considerable examples of aged persons among us, is of old *Parre* of *Sbropshire*, who lived 152 years 9 months, according to the learned *Dr. Harvey's* account ; and *Henry Jenkins* of *Yorkshire*, who lived 169 years, according to the account of my learned and ingenious friend *Dr. Tancred Robinson* : Of both which, with others, see *Lowth. abridg. Philos. Transf. V.* 3. *p.* 306. The great age of *Parre* of *Sbropshire*, minds me of an observation of the reverend *Mr. Plaxton*, that in his two parishes of *Kinardsey* and *Donington* in *Sbropshire*, every sixth soul was sixty years of age, or upwards. *Phil. Transf. N°* 310.

And if we step farther north into *Scotland*, we shall find divers recorded for their great age : Of which I shall present the reader with only one modern example of one *Laurence*, who married a wife after he was 100 years of age, and would go out to sea a fishing in his little boat, when he was 140 years

empty. For if men (the generality of them I mean)

years old ; and is lately dead of no other distemper but mere old age, saith Sir Rob. Sibbald, *Prodr. bist. nat. Scot. p. 44. l. 3. p. 4.*

As for foreigners, the examples would be endless ; and therefore that of *Job. Ottele* shall suffice, who was as famous for his beard, as for being 115 years of age. He was but two *Brabant* ells 3-9ths high ; and his long grey beard was one ell 1-4th long. His picture and account may be seen in *Ephem. Germ. T. 3. Obs. 163.*

As for the story *Roger Bacon* tells, of one that lived 900 years by the help of a certain medicine, and many other such stories, I look upon them as fabulous. And no better is that of the Wandering Jew, named *Job. Buttadaus*, said to have been present at our Saviour's crucifixion ; although very serious stories are told of his being seen at *Antwerp*, and in *France*, about the middle of the last century but one ; and before in Ann. 1542, conversed with by *Paul of Eitsen*, bishop of *Sleswick* ; and before that, viz. in 1228, seen and conversed with by an Armenian Archbishop's Gentleman ; and by others at other times.

If the reader hath a mind to see more examples, he may meet with some of all ages, in the learned *Hakerwill's Apol. p. 181.* where he will also find that learned author's opinion of the causes of the brevity and length of human life. The brevity thereof he attributeth to a tender education, sucking strange nurses, too hasty marriages ; but above all, to luxury, high sauces, strong liquors, &c. The longevity of the ancients he ascribes to temperance in meat and drink, anointing the body, the use of saffron and honey, warm cloaths, lesser doors and windows, less physick, and more exercise.

mean) were to live now to Methuselah's age of 969 years, or only to Abraham's long after the flood, of 175 years, the world would be too much over-run ; or if the age of man was limited to that of divers other animals, to ten, twenty, or thirty years only ; the decays then of mankind would be too fast : But at the middle rate mentioned, the balance is nearly even, and life and death keep an equal pace. Which equality is so great and harmonious, and so manifest an instance of the divine management, that I shall spend some remarks upon it.

It appears from our best accounts of these matters, that in our European parts (f), and I be-

(f) The proportions which Marriages bear to Births, and Births to Burials, in divers parts of Europe, may be seen at an easy view in this Table.

Name of the Places.	Marri. to births: as	Births to burials: as
England in general.	1 to 4'63	1'12 to 1
London.	1 to 4'	1 to 1'1
Hantsbire, from 1569, to 1658.	1 to 4'	1'2 to 1
Tiverton in Devon. 1560 to 1649.	1 to 3'7	1'26 to 1
Cranbrook in Kent, 1560, to 1649.	1 to 3'9	1'6 to 1
Aynbo in Northamptonsh. for 118 years	1 to 6	1'6 to 1
Leeds in Yorkshire for 122 years.	1 to 3'7	1'7 to 1
Harwood in Yorkshire 57 years.	1 to 3'4	1'23 to 1
Upminster in Essex 100 years.	1 to 4'6	1'08 to 1
Frankfort on the Main in 1695.	1 to 3'7	1'2 to 1
Old, mid. and lower Marck in 1698.	1 to 3'7	1'9 to 1
Dom. of the K. of Prussia in 1698.	1 to 3'7	1'5 to 1
Breslaw in Siles. from 1687, to 1691.		1'6 to 1
Paris in 1670, 1671, 1672.	1 to 4'7	1' to 1'6
		Which

I believe the same is throughout the world; that, I say, there is a certain rate and proportion in the propagation of mankind: Such a number marry (*g*), so many are born, such a number die; in proportion to the number of persons

Which table I made from Major *Graunt's* observations on the bills of mortality; Mr. *King's* observations in the first of Dr. *Davenant's* essays; and what I find put together by my ingenious friend Mr. *Louthborp*, in his abridgment, Vol. III. p. 668. and my own register of *Upminster*. That from *Aynbo's* register in *Northamptonshire*, I had from the present rector, the learned and ingenious Mr. *Wasse*: And I was promised some accounts from the north, and divers other parts of this kingdom; but have not yet receiv'd them: Only those of *Leeds* and *Harwood* in *Yorkshire*, from my curious and ingenious friend Mr. *Thoresby*.

(*g*) The preceding table shews, that marriages, one with another, do each of them produce about four births; not only in *England*, but in other parts of *Europe* also.

And by Mr. *King's* estimate (the best computations I imagine of any, being derived from the best accounts; such as the marriage, birth, burial-act, the poll-books, &c. by his estimate (I say) about 1 in 104 marry. For he judgeth the number of the people in *England* to be about five millions and a half; of which about 41000 annually marry. As to what might be farther remarked concerning marriages, in regard of the rites and customs of several nations, the age to which divers nations limited marriages, &c. it would be endless, and too much out of the way to mention them: I shall only



persons in every nation, country, or parish. And as to births, two things are very considerable: One is the proportion of males and females (*b*), not in a wide proportion, not an uncertain,

therefore, for the reader's diversion, take notice of the jeer of *Laëtantius*; 'Quare apud poëtas falacissimus Jupiter desiit liberos tollere? Utrum sexagenarius factus, & ei Lex Papia fibulam imposuit?' *Laëtant. Instit. l. 1. c. 16.* By which Lex Papia, men were prohibited to marry after 60, and women after 50 years of age.

(*b*) Major *Graunt* (whose conclusions seem to be well-grounded) and Mr. *King*, disagree in the proportions they assign to males and females. This latter makes in *London*, 10 males to 13 females; in other cities and market-towns, 8 to 9; and in the villages and hamlets, 100 males to 99 females. But Major *Graunt*, both from the *London*, and Country bills, saith, there are 14 males to 13 females: From whence he justly infers, 'That christian religion, prohibiting polygamy, is more agreeable to the law of nature than Mahumetism, and others that allow it,' *chap. 8.*

This proportion of 14 to 13, I imagine, is nearly just, it being agreeable to the bills I have met with, as well as those in Mr. *Graunt*. In the 100 years, for example, of my own parish-register, although the burials of males and females were nearly equal, being 636 males, and 623 females, in all that time; yet there were baptized 709 males, and but 675 females, which is 13 females to 13'7 males. Which inequality shews, not only, that one man ought to have but one wife; but also that every woman may, without polygamy, have an husband,

if

uncertain, accidental number at all adventures, but nearly equal. Another thing is, that a few more are born than appear to die, in any certain place (i). Which is an admirable provision

if she doth not bar herself by the want of virtue, by denial, &c. Also this surplufage of males is very useful for the supplies of war, the seas, and other such expences of the men above the women.

That this is a work of the divine providence, and not a matter of chance, is well made out by the very laws of chance, by a person able to do it, the ingenious and learned Dr. *Arbutnot*. He supposeth *Thomas* to lay against *John*, that for eighty-two years running, more males shall be born than females; and giving all allowances in the computation to *Thomas*'s side, he makes the odds against *Thomas*, that it doth not happen so, to be near five millions of millions, of millions, of millions to one; but for ages of ages (according to the world's age) to be near an infinite number to one against *Thomas*. *Vide Philos. Transf.* N<sup>o</sup> 338.

(i) The foregoing table shews, that in *England* in general, fewer die than are born, there being but one death to one twelfth of a hundred births. But in *London* more die than are born. So by Dr. *Davenant*'s table, the cities likewise and market-towns bury one seventh of a hundred to one birth. But in *Paris* they out-do *London*, their deaths being one and a half to one birth: The reason of which I conceive is, because their houses are more crowded than in *London*. But in the villages of *England*, there are fewer die than are born, there being but one death to one seventeenth of a hundred births. And yet Major *Graunt*, and Dr. *Davenant*, both observe, that there

vision for the extraordinary emergences and occasions of the world ; to supply unhealthful places, where death out-runs life ; to make up the ravages of great plagues and diseases, and the depredations of war, and the seas ; and to afford a sufficient number for colonies in the unpeopled parts of the earth. Or on the other hand, we may say, that sometimes those extraordinary expences of mankind may be not only a just punishment of the sins of men, but also a wise means to keep the balance of mankind even ; as one would be ready to conclude, by considering the Asiatick, and other the most fertile countries, where prodigious multitudes are yearly swept away with great plagues, and sometimes war ; and yet those countries are so far from being wasted, that they remain full of people.

And now, upon the whole matter, what is all this but admirable and plain management ? What can the maintaining, through-  
out

there are more breeders in *London*, and the cities and market-towns, than are in the country, notwithstanding the *London*-births are fewer than the country ; the reason of which see in *Graunt*, chap. 7. and *Davenant*, ubi supra, p. 21.

The last remark I shall make from the foregoing table, shall be, that we may from thence judge of the healthfulness of the places there mentioned. If the year 1698 was the mean account of the three *Marcks*, those places bid the fairest for being most healthful ; and next to them *Aynbo* and *Cranbrook*, for English towns,

out all ages and places, these proportions of mankind, and all other creatures; this harmony in the generations of men be, but the work of one that ruleth the world? Is it possible that every species of animals should so evenly be preserved, proportionate to the occasions of the world? That they should be so well balanced in all ages and places, without the help of Almighty wisdom and power? How is it possible, by the bare rules, and blind acts of nature, that there should be any tolerable proportion; for instance, between males and females, either of mankind, or of any other creature (*k*); especially such as are of a ferine, not of a domestick nature, and consequently out of the command and management of man? How could life and death keep such an even pace through all the animal world, if we should take it for granted, that, according to the scripture-history, the world had a beginning (as who can deny it (*l*)? or if

(*k*) ' Quid loquar, quanta ratio in bestiis ad perpetuam conservationem earum generis appareat? ' Nam primum aliæ mares, aliæ foeminæ sunt, ' quod perpetuitatis causâ machinata natura est.' Cic. *de nat. deor.* l. 2. c. 51.

(*l*) Altho' *Aristotle* held the eternity of the world, yet he seems to have retracted that opinion, or to have had a different opinion when he wrote his *Metaphysicks*; for in his first book he affirms, that ' God is the cause and beginning of all things; ' and in his book *de mundo* he saith, ' There is no ' doubt,

if we should suppose the destruction thereof by Noah's flood: how is it possible, after the world was replenished, that in a certain number of years, by the greater increases and doublings of each species of animals, that, I say, this rate of doubling (*m*) should cease; or, that it should be compensated by some other

'doubt but God is the maker and conservator of all things in the world.' And the Stoicks opinion is well known, who strenuously contended, that the contrivance and beauty of the heavens and earth, and all creatures, was owing to a wise, intelligent agent. Of which *Tully* gives a large account in his second book *de nat. deor.* in the person of *Balbus*.

(*m*) I have before in note (*g*), observed, That the ordinary rate of doubling or increase of mankind is, that every marriage, one with another, produces about four births; but some have much exceeded that. *Babo*, earl of *Abensperg*, had thirty-two sons and eight daughters; and being invited to hunt with the emperor *Henry II.* and bring but few servants, brought only one servant, and his thirty-two sons. To these many others might be added; but one of the most remarkable instances I have any where met with, is that of *Mrs. Honywood*, mentioned by *Hakerwill*, *Cambden*, and other authors; but having now before me the names, with some remarks (which I received from a pious neighbouring descendant of the same *Mrs. Honywood*) I shall give a more particular account than they. *Mrs. Mary Honywood* was daughter, and one of the co-heiresses of *Robert Atwaters*, Esq; of *Lenham* in *Kent*. She was born in 1527, married in February

other means : That the world should be as well, or better stocked than now it is, in 1656 years (the time between the creation and the flood ; this) we will suppose may be done by the natural method of each species doubling or increase : But in double that number of years, or at this distance from the flood, of 4000 years,

1543, at sixteen years of age, to her only husband Robert Honywood, of Charing in Kent, Esq; She died in the ninety-third year of her age, in May, 1620. She had sixteen children of her own body, seven sons and nine daughters ; of which one had no issue ; three died young, and the youngest was slain at Newport battle, June 20, 1600. Her grand-children, in the second generation, were one hundred and fourteen ; in the third, two hundred and twenty-eight ; and nine in the fourth generation. So that she could say the same that the distich doth, made of one of the Dalburg's family of Basil :

1 2 3 4  
Mater ait Natæ, dic Natæ, filia Natam

5 6  
Ut moneat, Natæ, plangere Filiolam.

1 2 3  
Rise up Daughter, and go to thy Daughter, for her

4 5 6  
Daughter's Daughter hath a Daughter.

Mrs. Honywood was a very pious woman, afflicted, in her declining age, with despair, in some measure ; concerning which some divines once discoursing with her, she in a passion said, ' She was as certainly damned as this glass is broken,' (throwing a Venice glass against the ground, which she had then in her hand.) But the glass escaped breaking, as credible witnesses attested.



years, that the world should not be overstocked, can never be made out, without allowing an infinite providence.

I conclude then this observation with the Psalmist's words, *Psal.* civ. 29, 30: 'Thou  
' hidest thy face, all creatures are troubled;  
' thou takest away their breath, they die, and  
' return to their dust. Thou sendest forth  
' thy spirit, they are created; and thou re-  
' newest the face of the earth.



# C H A P. XI.

## *Of the Food of Animals.*

**T**HE preceding reflection of the Psalmist mindeth me of another thing in common to animals, that pertinently falleth next under consideration, which is, the Appointment of Food, mentioned in Verse 27, 28. of the last cited Psalm civ. These  
' [Creatures] wait all upon thee, that thou  
' mayest give them their meat in due season. That thou givest them, they gather;  
' thou openest thy hand, they are filled with  
' good.' The same is again asserted in *Psal.* cxlv. 15, 16. 'The eyes of all wait upon  
' thee, and thou givest them their meat in due  
' season. Thou openest thy hand, and satisfiest the desire of every living thing.'

What the Psalmist here asserts, affords us a glorious scene of the divine providence and  
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management. Which (as I have shewed it to concern itself in other lesser things ; so) we may presume doth exert itself particularly in so grand an affair as that of food, whereby the animal world subsists : and this will be manifested, and the Psalmist's observations exemplified, from these six following particulars.

I. From the subsisting and maintaining such a large number of animals, throughout all parts of the world.

II. From the proportionate quantity of food to the eaters.

III. From the variety of food suited to the variety of animals ; or, the delight which various animals have in different food.

IV. From the peculiar food which peculiar places afford to the creatures suited to those places.

V. From the admirable and curious apparatus made for the gathering, preparing, and digestion of the food. And,

VI. and lastly, From the great sagacity of all animals, in finding out and providing their food.

I. It is a great act of the divine power and wisdom, as well as goodness, to provide food for such a world of animals (*a*), as every where possess

(*a*) ' Pastum animantibus largè & copiosè natura eum, qui cuique aptus erat, comparavit.' Cic. de nat. deor. l. 2. c. 47.

possess the terraqueous globe ; on the dry land ; and in the sea and waters ; in the torrid and frozen zones, as well as the temperate. That the temperate climates, or at least the fertile vallies, and rich and plentiful regions of the earth, should afford subsistence to many animals, may appear less wonderful perhaps : but that in all other the most likely places for supplies, sufficient food should be afforded to such a prodigious number, and so great variety of beasts, birds, fishes, and insects, is owing to that being, who hath as wisely adapted their bodies to their place and food, as well and carefully provided food for their subsistence there.

But I shall leave this consideration, because it will be illustrated under the following points ; and proceed,

II. To consider the adjustment of the quantity of food, in proportion to the eaters. In all places there is generally enough ; nay, such a sufficiency, as may be stiled a plenty ; but not such a superfluity, as to waste and corrupt, and thereby annoy the world. But that which is particularly remarkable here, is, that among the great variety of foods, the most useful is the most plentiful, most universal, easiest propagated, and most patient of weather, and other injuries. As the herbaceous eaters  
(for

‘ Ille Deus est,---- qui per totum orbem armenta  
‘ dimisit, qui gregibus ubique passim vagantibus  
‘ pabulum præstat.’ Senec. *de benef.* l. 4. c. 6.

(for instance) are many, and devour much ; so the dry-land surface we find every where almost naturally carpeted over with grass, and other agreeable wholesome plants ; propagating themselves in a manner every where, and scarcely destroyable by the weather, the plough, or any art. So likewise for grain, especially such as is most useful, how easily is it cultivated, and what a large increase doth it produce ? *Pliny's* example of wheat (*b*), is a sufficient instance in this matter ; which (as that curious heathen observes) being principally useful to the support of man, is easily propagated, and in great plenty : And an happy faculty that is of it, that it can bear either extreams of heat or cold, so as scarce to refuse any clime.

III. Another wise provision the Creator hath made relating to the food of animals, is, that various animals delight in various food (*c*) ; some in grass and herbs ; some in grain

(*b*) ' *Tritico nihil est fertilius : hoc ei natura tribuit, quoniam eo maximè alat hominem ; utpote cùm è modio, si sit aptum solum-----150 modii reddantur. Misit D. Augusto procurator ----ex uno grano (vix credibile dictu) 400 paucis minùs germina. Misit & Neroni similiter 340 stipulas ex uno grano.* *Plin. nat. hist. l. 18. c. 10.*

(*c*) ' *Sed illa quanta benignitas naturæ, quòd tam multa ad vescendum, tam varia, tam jucunda gignit ; neque ea uno tempore anni, ut semper & novitate delectemur & copiâ.* *Cic. de nat. deor.*

*l. 2. c. 53.*

grain and seeds; some in flesh; some in insects; some in this (*d*), some in that; some more delicate and nice; some voracious and catching at any thing. If all delighted in, or subsisted only with one sort of food, there would not be sufficient for all; but every variety chusing various food, and perhaps abhorring that which others like, is a great and wise means that every kind hath enough, and oftentimes somewhat to spare.

It deserves to be reckoned as an act of the divine appointment, that what is wholesome food to one, is nauseous, and as a poison to another; what is a sweet and delicate smell and taste to one, is foetid and loathsome to another: by which means all the provisions the globe affords, are well disposed of. Not only every creature is well provided for, but a due consumption is made of those things that

(*d*) *Swammerdam* observes of the *Ephemeron*-worms, that their food is clay, and that they make their cells of the same. Upon which occasion he saith of Moths, that eat wool and fur, 'There are two things very considerable, 1. That the cells they make to themselves, wherein they live, and with which (as their house, Tortoise-like) they move from place to place, they make of the matter next at hand. 2. That they feed also on the same: therefore when you find their cells, or rather coats or cases, to be made of yellow, green, blue, or black cloth, you will also find their dung of the same colour.' *Swam. Ephem. vita*, published by Dr. *Tyson*, chap. 3.

that otherwise would encumber the world, lie in the way, corrupt, rot, stink, and annoy, instead of cherishing and refreshing it. For our most useful plants, grain, and fruits, would mould and rot; those beasts, fowls, and fishes, which are reckoned among the greatest dainties, would turn to carrion, and poison us: Nay, those animals which are become carrion, and many other things that are noisome, both on the dry-land, and in the waters, would be great annoyances, and breed diseases, was it not for the provision which the infinite orderer of the world hath made, by causing these things to be sweet, pleasant, and wholesome food to some creature or other, in the place where those things fall: To dogs, ravens, and other voracious animals, for instance, on the earth; and to rapacious fishes, and other creatures inhabiting the waters.

Thus is the world, in some measure, kept sweet and clean, and at the same time, divers species of animals supplied with convenient food. Which providence of God, particularly in the supplies afforded the ravens, is divers times taken notice of in the scriptures.<sup>(c)</sup>; but whether for the reasons now hinted, or any other special reasons, I shall not enquire. Thus our Saviour, *Luke* xii. 24. 'Consider the ravens; for they neither sow nor reap, which neither have store-house, nor barn, and

(c) *Job* xxxviii. 41. *Psal.* cxlvii. 9.



‘and God feedeth them.’ It is a manifest argument of the divine care and providence, in supplying the world with food and necessities, that the ravens, accounted as unclean, and little regarded by man, destitute of stores, and that live by accidents, by what falleth here and there ; that such a bird, I say, should be provided with sufficient food ; especially if that be true which *Aristotle* (f), *Pliny* (g), and *Ælian* (b) report, of their unnatural affection and cruelty to their young ; ‘That they expel them their nests as soon as they can fly, and then drive them out of the country.’

Thus having considered the wise appointment of the Creator, in suiting the variety of food to variety of animals, let us in the

IV. place, take a view of the particular food, which particular places afford to the creatures inhabiting therein.

It hath been already observed (i), that every place on the surface of the terraqueous globe, is stocked with proper animals, whose organs of life and action are curiously adapted to each respective place. Now it is an admirable act of the divine providence, that every place affords

(f) *Aristot.* l. 9. c. 31. *Hist. animal.*

(g) *Pliny* affirms this of the Crow as well as Raven : ‘Cæteræ omnes [i. e. Cornices] ex eodem genere pellunt nidis pullos, ac volare cogunt, sicut & corvi, qui---robustos suos foetus fugant longius.’ *Nat. hist.* l. 10. c. 12.

(b) *Var. Hist.*

(i) *Chap.* 9.

fords a proper food to all the living creatures therein. All the various regions of the world, the different climates (*k*), the various soils, the seas, the waters, nay our very putrefactions, and most nasty places about the globe, as they are inhabited by some or other animal, so they produce some proper food or other, affording a comfortable subsistence to the creatures living there. I might, for instances (*l*) of this, bring the great variety of herbs, fruits and grains

(*k*) 'Admiranda naturæ dispensatio est, ut aliter, alioque modo, tempore, & industriâ colatur terra septentrionalis, aliter Æthiopia, &c. Quoad Aquilonares, hoc certum est, in plerisque agris Vestrogothorum, parte objectâ meridionali plagæ, hordeum spatio 36 dierum à semine projecto maturum colligi, hoc est, à fine Junii usque medium Augusti, aliquando celerius. Ea namque maturitas ex soli naturâ, aërisque clementiâ, ac humore lapillorum sovente radices, soleque torrente, necessariò provenit, ut ita nascatur, ac maturetur, talesque spicæ sex ordines in numero aristæ habent.' *Ol. Mag. Hist. l. 15. c. 8.* 'Prata & pasoua tantâ luxuriant graminum ubertate ac diversitate, ut necessum sit inde arcere jumenta, ne nimio herbarum usu crepent, &c. *Id. ib. l. 19. c. 36.*

(*l*) Among the many noble contrivances for food, I cannot but attribute that universal aliment, Bread, to the revelation, or at least the inspiration of the creator and conservator of mankind; not only because it is a food used in all, or most parts of the world; but especially because it is of incomparable use

grains on the earth, the large swarms of insects in the air, with every food of the creatures residing in the earth, or flying in the air: But I shall stop at the waters, because the Psalmist, in the fore-cited civth Psalm, speaks with relation to the especial provision for the inhabitants of the waters; and also by reason that many land-animals have their chief maintenance from thence.

Now one would think, that the waters were a very unlikely element to produce food for so great a number of creatures, as have their subsistence from thence. But yet how rich a promptuary is it, not only to large multitudes of fishes, but also to many amphibious quadrupeds, insects, reptiles, and birds! From the largest Leviathan, which the Psalmist saith (*m*) 'playeth in the seas,' to the smallest mites in the lakes and ponds, all are plentifully provided for; as is manifest from the fatness of their bodies, and the gaiety of their aspect and actions. And

use in the great work of digestion, greatly assisting the ferment, or whatever causes the digestion of the stomach. Of which take this example from the noble Mr. Boyle. 'He extracted a Menstruum from bread alone, that would work on bodies more compact than many hard minerals, nay even on glass itself, and do many things that Aqua-fortis could not do----Yet by no means was this so corrosive a liquor as Aqua-fortis, or as the other acid Menstruum.' See the ingenious and learned Dr. Harris's *Lex. Tech. verbo Menstruum*, where the way of preparing it may be met with.

(*m*) *Psal. civ. 26.*

And the provision which the Creator hath made for this service in the waters, is very observable; not only by the germination of divers aquatick plants there, but particularly by appointing the waters to be the matrix of many animals, particularly of many of the insect-kind, not only of such as are peculiar to the waters, but also of many appertaining to the air and the land, who, by their near alliance to the waters, delight to be about them, and by that means become a prey, and plentiful food to the inhabitants of the waters. And besides these, what prodigious shoals do we find of minute animals, even sometimes discolouring the waters (n)! Of these (not only

(n) The insects that for the most part discolour the waters, are the small insects of the Shrimp-kind, called by *Swammerdam*, *Pulex aquaticus arborescens*. These I have often seen so numerous in stagnating waters in the summer months, that they have changed the colour of the waters to a pale or deep red, sometimes a yellow, according to the colour they were of. Of this *Swammerdam* hath a pretty story told him by *Dr. Florence Schuyt*; viz. 'Se aliquando studiis intentum, magno quodam & horrifico rumore fuisse turbatum, & simul ad causam ejus inquirendam excitatum; verum se vix eum in finem surrexisse, cum Ancilla ejus pœne exanimis adcurreret, & multo cum singultu referret, omnem Lugduni [*Bataworum*] aquam esse mutatam in sanguinem.' The cause of which, upon examination, he found to be only from the numerous

only in the water, but in the air and on land) I have always thought there was some more than ordinary use intended by the all-wise Creator. And having bent many of my observations that way, I have evidently found it accordingly to be. For be they ever so numberless or minute, those animals serve for food to some creatures or other. Even those animalcules in the waters, discoverable only with good microscopes, are a repast to others there, as I have often, with no less admiration than pleasure, seen (o). But

rous swarms of those Pulices. *Vide Swamm. bish. insect. p. 70.*

The cause of this great concourse and appearance of those little insects, I have frequently observed to be to perform their coit; which is commonly about the latter end of *May*, and in *June*. At that time they are very venereous, frisking and catching at one another; and many of them conjoined tail to tail, with their bellies inclined one towards another.

At this time also they change their skin or slough; which I conceive their rubbing against one another mightily promoteth. And what if at this time they change their quarters! See *book viii. chap. 4. note (f)*.

These small insects, as they are very numerous, so are food to many water animals. I have seen not only Ducks shovel them up as they swim along the waters, but divers insects also devour them, particularly some of the middle sized squillæ aquaticæ, which are very voracious insects.

(o) Besides the Pulices last mentioned, there are in the waters other animalcules very numerous, which

But now the usual objection is, that necessity maketh use (*p*). Animals must be fed, and they make use of what they find : In the desolate

which are scarce visible without a microscope. In May, and the summer months, the green scum on the top of stagnating waters, is nothing else but prodigious numbers of these animalcules : So is likewise the green colour in them, when all the water seems green. Which animalcules, in all probability, serve for food to the Pulices Aquatici, and other the minuter animals of the waters. Of which I gave a pregnant instance in one of the Nymphæ of Gnats, to my friend the late admirable Mr. Ray, which he was pleased to publish in the last edition of his *Wisdom of God in the Creation*, p. 430.

(*p*) *Nil addè quoniam natum' est in corpore, ut uti Possemus, sed quod natum' est, id procreat usum.*

And afterwards,

*Propterea capitur cibus, ut suffulciat artus,*

*Et recreet viridis interdatus, atque patentem*

*Per membra ac venas ut amorem obturet edendi.*

And after the same manner he discourseth of thirst, and divers other things. *Vid. Lucret. l. 4. v. 831. &c.*

Against this opinion of the Epicureans, *Galen* ingeniously argues in his discourse about the hand.

' Non enim manus ipsæ (saith he) hominem artes docuerunt, sed ratio. Manus autem ipsæ sunt artium organa ; sicut Lyra musici-----Lyra musicam non docuit, sed est ipsius artifex per eam, quâ præditus est, rationem : agere autem non potest ex arte absque organis, ita & una quælibet anima facultates quasdam à suâ ipsius substantiâ obtinet-----Quòd autem corporis particule api-  
mam



desolate regions, and in the waters, for instance, they feed upon what they can come at; but, when in greater plenty, they pick and chuse.

But this objection hath been already in some measure answered by what hath been said; which plainly argues design, and a superintending wisdom, power and providence in this special business of food. Particularly the

‘mam non impellunt,-----manifestè videre licet, si  
 ‘animalia recens nata consideres, quæ quidem prius  
 ‘agere conantur, quàm perfectas habeant particu-  
 ‘las. Ego namque Bovis vitulum cornibus petere  
 ‘conantem sæpenumero vidi, antequam ei nata es-  
 ‘sent cornua; & pullum equi calcitrantem, &c.  
 ‘Omne enim animal suæ ipsius animæ facultates,  
 ‘ac in quos usus partes suæ polleant maximè, nullo  
 ‘doctore, præsentit.----- Quâ igitur ratione dici  
 ‘potest, animalia partium usus à partibus doceri,  
 ‘cùm & antequam illas habeant, hoc cognoscere  
 ‘videantur? Si igitur ova tria acceperis, unum  
 ‘aquilæ, alterum anatis, reliquum serpentis, &  
 ‘calore modico foveris, animaliaque excluseris;  
 ‘illa quidem alis volare conantia, antequam volare  
 ‘possint; hoc autem revolvi videbis, & serpere as-  
 ‘sectans, quamvis molle adhuc & invalidum fuerit.  
 ‘Et si, dum perfecta erunt, in unâ eâdemque domo  
 ‘nutraveris, deinde ad locum subdialem ducta emise-  
 ‘ris, aquila quidem ad sublime; anas autem in  
 ‘paludem; ---- serpens verò sub terra irrepet-  
 ‘animalia quidem mihi videntur naturâ magis quàm  
 ‘ratione artem aliquam [*τεχνην* artificiosam] exer-  
 ‘cere: Apes fingere alveolos, &c.’ Galen. *de usu*  
*part. I. c. 3.*

the different delight of divers animals in different food ; so that what is nauseous to one, should be dainties to another, is a manifest argument, that the allotment of food is not a matter of mere chance, but entailed to the very constitution and nature of animals ; that they chuse this, and refuse that, not by accident, or necessity, but because the one is a proper food, agreeable to their constitution, and so appointed by the infinite contriver of their bodies ; and the other is disagreeable and injurious to them.

But all this objection will be found frivolous, and the wisdom and design of the great Creator will demonstratively appear, if we take a survey,

V. Of the admirable and curious apparatus in all animals, made for the gathering, preparing and digestion of their food. From the very first entrance to the utmost exit of the food, we find every thing contrived, made and disposed with the utmost dexterity of art, and curiously adapted to the place the animal liveth in, and the food it is to be nourished with.

Let us begin with the Mouth. And this we find in every species of animals, nicely conformable to the use of such a part ; neatly sized and shaped for the catching of prey, for the gathering and receiving food (g), for the

(g) ' Alia dentibus prædantur, alia unguibus,  
' alia rostri aduncitate carpunt, alia latitudine

the formation of speech, and every other such like use (r). In some creatures it is wide and large, in some little and narrow; in some with a deep incisure up into the head (s), for the better catching and holding of prey, and more easy comminution of hard, large and troublesome food; in others with a much shorter incisure, for the gathering and holding of herbaceous food. In

‘ [ejusdem] ruunt, alia acumine excavant, alia sugunt, alia lambunt, sorbent, mandunt, vorant. Nec minor varietas in pedum ministerio, ut rapiant, distrahant, teneant, premant, pendeant, tellurem scabere non cessent.’ Plin. nat. hist. l. 10. c. 71.

(r) Because it would be tedious to reckon up the bones, glands, muscles, and other parts belonging to the mouth, it shall suffice to observe, that, for the various services of man’s mouth, besides the muscles in common with other parts, there are five pair, and one single one proper to the lips only, as Dr. Gibson reckons them: But my most diligent and curious friend the late Mr. Cowper, discovered a sixth pair. And accordingly Dr. Drake reckons six pair, and one single one proper to the lips, l. 3. c. 13.

(s) Galen deserves to be here consulted, who excellently argues against the casual concurrence of the atoms of Epicurus and Asclepiades, from the provident and wise formation of the mouths of animals, and their teeth answerable thereto. In man, his mouth without a deep incisure, with only one canine tooth on a side, and flat nails, because, saith he, ‘ Hic natura certò sciebat, se animal mansuetum ac civile effingere, cui robur & vires essent ex sapientiâ,

In Insects it is very notable. In some forcipated, to catch hold and tear their prey (t). In some aculeated, to pierce and wound animals (u), and suck their blood. And in others

‘sapientia, non ex corporis fortitudine.’ But for Lions, Wolves and Dogs, and all such as are called *Kαρφαῖδες* (or having sharp, ferrated teeth) their mouths are large, and deep cut; teeth strong and sharp, and their nails sharp, large, strong and round, accommodated to holding and tearing. *Vid. Galen de us. part. l. 11. c. 9.*

(t) Among insects, the *Squilla aquatica*, as they are very rapacious, so are accordingly provided for it: particularly the *Squilla aquatica maxima recurva* (as I call it) who hath somewhat terrible in its very aspect, and in its posture in the water, especially its mouth, which is armed with long, sharp hooks, with which it boldly and greedily catcheth any thing in the waters, even one's fingers. When they have seized their prey, they will so tenaciously hold it with their forcipated mouth, that they will not part therewith, even when they are taken out of the waters, and jumbled about in one's hand. I have admired at their peculiar way of taking in their food; which is done by piercing their prey with their forceipes (which are hollow) and sucking the juice thereof through them.

The *Squilla* here mentioned, is the first and second in *Moufet's Treat. Insect. l. 2. c. 37.*

(u) For an instance of insects endued with a spear, I shall, for its peculiarity, pitch upon one of the smallest, if not the very smallest, of all the Gnat-kind, which I call, *Culex minimus nigricans maculatus sanguisuga*. Among us in *Essex*, they are called Ni-

others strongly rigged with jaws and teeth, to gnaw and scrape out their food, to carry burdens (*w*), to perforate the earth, yea the hardest

diots (by *Mouffet*, Midges.) It is about one tenth of an inch, or somewhat more, long, with short Antennæ, plain in the female, in the male feather'd, somewhat like a bottle-brush. It is spotted with blackish spots, especially on the wings, which extend a little beyond the body. It comes from a little slender eel-like worm, of a dirty white colour, swimming in stagnating waters by a wrigling motion; as in *fig. 5*.

Its Aurelia is small, with a black head, little short horns, a spotted, slender, rough belly. *Vid. fig. 6*. It lies quietly on the top of the water, now and then gently wagging itself this way and that.

These gnats are greedy blood-suckers, and very troublesome, where numerous; as they are in some places near the *Tbames*, particularly in the breach-waters, that have lately befallen near us, in the parish of *Dagenham*; where I found them so vexatious, that I was glad to get out of those marshes. Yea, I have seen horses so stung with them, that they have had drops of blood all over their bodies, where they were wounded by them.

I have given a figure (in *fig. 7*.) and more particular description of the gnats, because, although it be common, it is no where taken notice of by any author I know, except *Mouffet*, who, I suppose, means these gnats, which he calls Midges, c. 13. p. 82.

(*w*) Hornets and Wasps have strong jaws, toothed, wherewith they can dig into fruits, for their food; as also gnaw and scrape wood, whole mouthfuls of which they carry away to make their combs. *Vide infr. chap. 13. note (e)*.

hardest wood, yea, even stones themselves, for houses (x) to themselves, and nests for their young.

And lastly, in Birds it is no less remarkable. In the first place, it is neatly shaped for piercing the air, and making way for the body thro' the airy regions. In the next place, it is hard and horny, which is a good supplement for the want of teeth, and causeth the bill to have the use and service of the hand. Its hooked form is of great use to the rapacious kind (y), in catching and holding their prey, and in the comminution thereof by tearing; to others it is no less serviceable to their climbing, as well as neat and nice comminution of their food (z). Its extraordinary length  
and

(x) Monsieur *de la Veye* tells of an ancient wall of free-stone in the *Benedictines-Abbey* at *Carm* in *Normandy*, so eaten with worms, that one may run one's hand into most of the cavities: That these worms are small and black, lodging in a greyish shell; that they have large flattish heads, a large mouth, with four black jaws, &c. *Phil. Trans.* N<sup>o</sup> 18.

(y) 'Proiis [*Labris*] cornea & acuta volucris  
'rostra. Eadem raptu viventibus adunca: collecto,  
'recta: herbas ruentibus limumque lata, ut suum  
'generi. Jumentis vice manûs ad colligenda pa-  
'bula: ora apertiora laniatu viventibus.' *Plin.*  
*Nat. hist. l. 11. c. 37.*

(z) Parrots have their bills nicely adapted to these services, being hooked, for climbing and reaching what they have occasion for; and the lower jaw



and slenderness is very useful to some, to search and grope for their food in moorish places (*aa*) ; as its length and breadth is to others, to hunt and search in muddy places (*bb*) : And the contrary form, namely, a thick, short, and sharp-edged bill, is as useful to other birds, who have occasion to husk and flay the grains they swallow. But it would be endless, and tedious, to reckon up all the various shapes, and commodious mechanism of all ; the sharpness and strength of those who have occasion to perforate wood and shells (*cc*) ; the slenderness and neatness of such

being compleatly fitted to the hooks of the upper, they can as minutely break their food, as other animals do with their teeth.

(*aa*) Thus in Woodcocks, Snipes, &c. who hunt for worms in moorish ground, and, as Mr. *Willoughby* saith, live also on the fatty unctuous humour they suck out of the earth. So also the bills of Curlews, and many other sea-fowl, are very long, to enable them to hunt for the worms, &c. in the sands on the sea-shore, which they frequent.

(*bb*) Ducks, Geese, and divers others, have such long broad bills, to quaffer and hunt in water and mud ; to which we may reckon the uncouth bill of the Spoon-Bill : But that which deserves particular observation in the birds named in these two last notes is, the nerves going to the end of their bills, enabling them to discover their food out of sight ; of which see *book vii. chap. 2. note (e)*.

(*cc*) The *Picus Viridis*, or Green Woodspite, and all the Wood-peckers, have bills curiously made for digging

such as pick up small insects ; the cross-form of such as break up fruits (*dd*) ; the compressed form of others (*ee*), with many other curious and artificial forms, all suited to the way of living, and peculiar occasions of the several species of birds. Thus much for the mouth.

Let us next take a short view of the Teeth (*ff*).  
In

digging wood, strong, hard, and sharp. A neat ridge runs along the top of the green Wood-pecker's bill, as if an artist had designed it for strength and neatness.

(*dd*) The Loxia, or Cross-bill, whose bill is thick and strong, with the tips crossing one another ; with great readiness breaks open fir-cones, apples, and other fruit, to come at their kernels, which are its food ; as if the crossing of the bill was designed for this service.

(*ee*) The Sea-Pie hath a long, sharp, narrow bill, compressed side-ways, and every way so well adapted to the raising Limpets from the rocks (which are its chief, if not only food) that nature (or rather the author of nature) seems to have framed it purely for that use.

(*ff*) ' Those animals which have teeth on both jaws, have but one stomach ; but most of those which have no upper teeth, or none at all, have three stomachs ; as in beasts, the paunch, the read, and the feck ; and in all granivorous birds, the crop, the echinus, and the gizzard. For as chewing is to an easy digestion, so is swallowing whole to that which is more laborious.' *Dr. Grew's Cosmol. Sacr. c. 5. § 24.*

In which their peculiar hardness (*gg*) is remarkable, their growth (*bb*) also, their firm insertion and bandage in the gums and jaws, and their various shape and strength, suited to their various occasions and use (*ii*); the foremost weak and farthest from the center, as being

(*gg*). *J. Peyer* saith, the teeth are made of convolved skins hardened; and if we view the grinders of Deer, Horses, Sheep, &c. we shall find great reason to be of his mind. His observations are, ‘*Mirum autem eos (i. e. dentes) cum primum è pelliculis imbricatim convolutis & mucò viscido constarent, in tantam dirigescere soliditatem, quæ ossa cuncta superet. Idem fit etiam in officulis ceraforum, &c.---Separatione factâ, per membranas conditur magna locellis, quos formant laminae tenues, ac duriusculæ, ad dentis figuram antea divinitus compositæ.*’ *J. Peyer Mergol. l. 2. c. 8.*

(*bb*) ‘*Qui autem (i. e. dentes) renascuntur, minime credendi sunt à facultate aliquâ plasticâ brutorum denuò formari, sed latentes tantummodo in conspectum producuntur augmento molis ex effluente succo.*’ *Id. ibid.*

(*ii*) From these, and other like considerations of the teeth, *Galen* infers, that they must needs be the work of some wise, provident being; not Chance, nor a fortuitous concurrence of atoms. For the confirmation of which he puts the case, That suppose the order of the teeth should have been inverted, the Grinders set in the room of the Incisors, &c. (which might as well have been, had not the teeth been placed by a wise agent) in this case, what use would the teeth have been of? What confusion by  
such

being only preparers to the rest; the others being to grind and mince, are accordingly made stronger, and placed nearer the center of motion and strength. Likewise their various form (*kk*), in various animals, is considerable, being all curiously adapted to the peculiar food (*ll*), and all occasions of the several

such a slight error in their disposal only? Upon which he argues, 'At si quis choream hominum 32 (the number of the teeth) ordine disposuit, eum ut hominem industrium laudaremus: cum verò dentium choream natura tam bellè exornavit, nonne ipsam quoque laudabimus?' And then he goes on with the argument, from the sockets of the teeth, and their nice fitting in them, which being no less accurately done, than what is done by a carpenter, or stone-cutter, in fitting a tenon into a mortice, doth as well infer the art and act of the wise Maker of animal bodies, as the other doth the act and art of man. And so he goes on with other arguments to the same effect. *Galen de us. part. l. 11. c. 8.*

(*kk*) A curious account of this may be found in an *Extract of a letter concerning the teeth of divers animals.* Printed at *Paris*, in *M. Vauguion's* compleat body of chirurg. oper. chap. 53.

(*ll*) As it hath been taken notice of, that various animals delight in various food; so it constantly falls out, that their teeth are accordingly fitted to their food; the rapacious to catching, holding and tearing their prey; the herbaceous to gathering and comminution of vegetables: And such as have no teeth, as birds, their bill, craw, and gizzard, are assisted with stones, to supply the defect of teeth.

But

veral species of animals (*mm*). And lastly, the temporary defect of them (*nn*), is no less observable in children, and such young creatures,

But the most considerable example of this kind is in some families of the insect-tribes, as the Papillio-kind, &c. who have teeth, and are voracious, and live on tender vegetables in their Nympha, or Caterpillar-state, when they can only creep; but in their mature Papillio-state, they have no teeth, but a Proboscis, or Trunk, to suck up honey, &c. their parts for gathering food, as well as their food, being changed, as soon as they have wings, to enable them to fly to it.

(*mm*) It is remarkable in the teeth of fishes, that in some they are sharp, as also jointed, so as to fall back, the better to catch and hold their prey, and to facilitate its passage into the stomach: So in others they are broad and flat, made to break the shells of snails and shell-fish devoured by them. These teeth, or breakers, are placed, in some, in the mouth; in some, in the throat; and in Lobsters, &c. in the stomach itself; in the bottom of whose stomachs are three of those grinders, with peculiar muscles to move them.

(*nn*) What is there in the world can be called an act of providence and design, if this temporary defect of teeth be not such? That children, for instance, should have none whilst they are not able to use them, but to hurt themselves, or the mother; and that at the very age when they can take in more substantial food, and live without the breast, and begin to need teeth, for the sake of speech; that then, I say, their teeth should begin to appear, and gradually grow, as they more and more stand in need of them.

tures, where there is no occasion for them; but they would be rather an annoyance to the tender nipples and breasts.

From the teeth, the grand instruments of mastication, let us proceed to the other ministerial parts. And here the parotid, sublingual, and maxillary glands, together with those of the cheeks and lips, are considerable; all lodg'd in the most convenient places about the mouth and throat; to afford that noble digestive salival liquor, to be mixed with the food in mastication, and to moisten and lubricate the passage, to give an easy descent to the food. The commodious form also of the jaws deserves our notice; together with the strong articulation of the lowermost, and its motion. And lastly, the curious form, the great strength, the convenient lodgment and situation of the several muscles and tendons<sup>(oo)</sup>, all ministering to this so necessary an act of life, as mastication is; they are such contrivances, such works, as plainly set forth the infinite workman's care and skill.

Next

(oo) It would be endless to particularize here, and therefore I shall refer to the anatomists; among the rest, particularly to *Galen*, for the sake of his descant upon this subject. For having described the great accuracy of the contrivance and make of these parts, he saith, 'Haud scio an hominum sit sobriorum ad fortunam opificem id revocare: alioqui quid tandem erit, quod cum providentiâ atque arte efficitur? Omnino enim hoc ei contrarium esse debet, quod casu ac fortuito fit,' *Galen, de us. part. l. 11. c. 7. ubi plura.*



Next to the mouth, the Gullet presenteth itself; in every creature well sized to the food it hath occasion to swallow; in some but narrow, in others as large and extensive (*pp*); in all exceedingly remarkable for the curious mechanism of its muscles, and the artificial decussation and position of their fibres (*qq*).

And

(*pp*) 'The bore of the gullet is not in all creatures alike answerable to the body or stomach. As in the Fox, which both feeds on bones, and swallows whole, or with little chewing; and next in a Dog, and other offivorous quadrupeds, 'tis very large; *viz.* to prevent a contusion therein. Next in a Horse, which though he feeds on grass, yet swallows much at once, and so requires a more open passage. But in a Sheep, Rabbit, or Ox, which bite short, and swallow less at once, 'tis smaller. And in a Squirrel, still lesser, both because he eats fine, and to keep him from disgorging his meat upon his descending leaps. And so in Rats and Mice, which often run along walls, with their heads downwards.' *Dr. Grew's Comp. Anat. of stom. and Guts, chap. 5.*

(*qq*) Of this see *Dr. Willis's Pharm. Rat. part 1. § 1. c. 2.* *Steno* also, and *Peyer. Mery. l. 2.*

The description these give of the muscular part of the gullet, the late ingenious and learned *Dr. Drake* saith, is very exact in ruminants, but not in men. In men, this coat (the second of the gullet) consists of two fleshy Lamellæ, like two distinct muscles. The outward being composed of strait longitudinal fibres.-----The inner order of fibres is annular, without any observable angles.-----

The use of this coat, and these orders of fibres,

is

And now we are arrived to the grand receptacle of the food, the Stomach ; for the most part as various as the food to be convey'd therein. And here I might describe the admirable mechanism of its tunicks, muscles, glands, the nerves, arteries, and veins (*rr*) ; all manifesting the super-eminent contrivance and art of the infinite workman (*ss*) ; they being all nicely adjusted to their respective place, occasion, and service. I might also insist upon that most necessary office of digestion ; and here consider that wonderful faculty of the stomachs of all creatures, to dissolve (*tt*) all the several sorts of food appropriated to their species ; even sometimes things of that consistency as

' is to promote deglutition ; of which the longitudinal,-----shorten the Oesophagus, and so make its capacity larger, to admit of the matter to be swallowed. The annular, on the contrary, contract the capacity, and closing behind the descending aliment, press it downwards.' Drake's *Anat.* vol. 1. l. 1. c. 9.

(*rr*) See Willis *ibid.* Cowper's *Anat.* Tab. 35. and many other authors.

(*ss*) ' Promptuarium autem hoc, alimentum universum excipiens, ceu divinum, non humanum fit opificium.' Galen. *de us. part.* l. 4. c. 1.

(*tt*) ' How great a comprehension of the nature of things, did it require, to make a Menstruum, that should corrode all sorts of flesh coming into the stomach, and yet not the stomach itself, which is also flesh ? Dr. Grew's *Cosmol.* Sac. c. 4.

as seem insoluble (*uu*); especially by such seemingly simple and weak Menstruums as we find in their stomachs.: But I shall only give these things a bare mention, and take more particular notice of the special provision made in the particular species of animals, for the digestion of that special food appointed them.

And in the first place it is observable, that in every species of animals, the strength and size

(*uu*) The food of the Castor being oftentimes, if not always, dry things, and hard of digestion, such as the roots and bark of trees, 'tis a wonderful provision made in that creature's stomach, by the digestive juice lodged in the curious little cells there. A description of whose admirable structure and order may be found in *Blasius* from *Wepfer*: concerning which he saith, 'In quibus mucus reconditus, non secus ac mel in favis.----- Nimirum quia castoris alimentum exsuccum, & coctu difficillimum est, sapientissimus & summè admirandus in suis operibus rerum conditor, D. O. M. ipsi pulcherrimâ istâ & affabrè factâ structurâ benignissimè prospexit, ut nunquam deesset fermentum, quod ad solvendum, & comminuendum alimentum durum & asperum par foret.' *Vide Blas. Anat. Animal. c. 10. Confer etiam Act. Erud. Lips. Ann. 1684. p. 360.*

Most of our modern anatomists and physicians attribute digestion to a dissolving Menstruum; but *Dr. Drake* takes it to be rather from fermentative, dissolving principles in the aliment itself, with the concurrence of the air and heat of the body; as in *Dr. Pajin's Digester. Vide Dr. Anat. vol. I. c. 14.*

size of their stomach (*www*) is conformable to their food. Such whose food is more delicate, tender, and nutritive, have commonly this part thinner, weaker and less bulky; whereas such whose aliment is less nutritive, or whose bodies require larger supplies to answer their bulk, their labours, and waste of strength and spirits, in them it is large and strong.

Another very remarkable thing in this part, is, the number of ventricles in divers creatures. In many but one; in some two or more (*xx*). In such as make a sufficient comminution of the food in the mouth, one suffices.

(*www*) ' All carnivorous quadrupeds have the ' smallest ventricles, flesh going farthest. Those ' that feed on fruits, and roots, have them of a ' middle size. Yet the Mole, because it feeds un- ' clean, hath a very great one. Sheep and Oxen, ' which feed on grass, have the greatest. Yet the ' Horse (and for the same reason the Coney and ' Hare) though graminivorous, yet comparatively ' have but little ones. For that a Horse is made ' for labour, and both this, and the Hare, for ' quick and continued motion; for which, the most ' easy respiration, and so the freest motion of the ' Diaphragm, is very requisite; which yet could ' not be, should the stomach lie big and cumber- ' some upon it, as in Sheep and Oxen it doth.' Grew *ibid.* chap. 6.

(*xx*) The Dromedary hath four stomachs, one whereof is peculiarly endowed with about twenty cavities, like sacks, in all probability, for the holding of water. Concerning which, see *book vi. chap. 4.* *note (a).*

**fices.** But where teeth are wanting, and the food dry and hard (as in granivorous birds) there the defect is abundantly supplied by one thin membranaceous ventricle, to receive and moisten the food, and another thick, strong, muscular one, to grind and tear (yy) it. But in such birds, and other creatures, whose food is not grain, but flesh, fruits, insects, or partly one, partly the other, there their stomachs are accordingly conformable to their food (zz), stronger or weaker, membranaceous or muscular.

But as remarkable a thing as any in this part of animals, is, the curious contrivance and fabrick of the several ventricles of ruminating creatures. The very act itself of Rumination, is an excellent provision for the compleat mastication of the food, at the resting, leisure times

(yy) To assist in which office, they swallow small angular stones, which are to be met with in the gizzards of all granivorous birds; but in the gizzard of the Lynx, or Wry-neck, which was full only of Ants, I found not one stone. So in that of the Green-wood Pecker (full of ants and tree-maggots) there were but few stones.

(zz) ' In the most carnivorous birds, the third ventricle is membranous; where the meat is concocted, as in a man: or somewhat tendinous, as in an Owl; as if it were made indifferently for flesh, or other meat, as he could meet with either: or most thick and tendinous, called the gizzard; wherein the meat, as on a mill, is ground to pieces.' Grew, *ubi supra*, chap. 9.

times of the animal. But the apparatus for this service, of divers ventricles for its various uses and purposes, together with their curious mechanism, deserves great admiration (*aaa*).

Having thus far pursued the food to the place, where, by its reduction into chyle, it becomes a proper aliment for the body; I might next trace it through the several mæanders of the guts, the lacteals, and so into the blood (*bbb*), and afterwards into the very

(*aaa*) It would be much too long a task to insist upon it here as it deserves; and therefore concerning the whole business of rumination, I shall refer to J. Conr. Peyer's *Merycolog. seu de ruminantibus & ruminatione commentar.* where he largely treateth of the several ruminating animals, of the parts ministering to this act, and the great use and benefit thereof unto them.

(*bbb*) There are too many particulars to be insisted on, observable in the passages of the Chyle, from the guts to the left Subclavian Vein, where it enters into the blood; and therefore I shall only, for a sample of this admirable oeconomy, take notice of some of the main and more general matters. And,

1. After the food is become chyle, and gotten into the guts, it is an excellent provision made, not only for its passage through the guts, but also for its protrusion into the Lacteals, by the Peristaltick motion, and Valvulæ Conniventes of the guts. 2. It is an admirable provision, that the mouths of the Lacteals, and indeed the Lactealis primi generis themselves, are small and fine, not wider than the Capillary Arteries are, lest by admitting particles of



very habit of the body : I might also take notice of the separation made in the Intestines, of what is nutritive (which is received) and what is feculent (being ejected) and the impregnations there from the Pancreas and the Gall; and after it hath been strained through those curious colanders, the lacteal Veins, I might also observe its impregnations from the Glands and Lymphæ-Ducts ; and, to name no more,

the nourishment grosser than the Capillaries, dangerous obstructions might be thereby produced.

3. After the reception of the aliment into the Lacteals primi generis, it is a noble provision for the advancement of its motion, that in the Mesenterick Glands, it meets with some of the Lymphæ-Ducts, and receives the impregnation of the Lympha. And passing on from thence, it is no less an advantage. 4. That the Lacteals and Lymphæ-Ducts meet in the Receptaculum Chyli, where the aliment meeting with more of the Lympha, is made of a due consistence and temperament, for its farther advancement through the Thoracick Duct, and so into the left Subclavian vein and blood. Lastly, this Thoracick Duct itself is a part of great consideration. For (as Mr. Cowper saith) ‘ If we consider in this duct its several divisions and inosculations, its numerous valves, looking from below upwards, its advantageous situation between the great artery and Vertebrae of the back, together with the ducts discharging their reflux Lympha from the lungs, and other neighbouring parts, we shall find all conduce to demonstrate the utmost art of nature used in furthering the steep and perpendicular ascent of the chyle.’ *Anat.*

*Introduci.*

more, I might farther view the exquisite structure of the parts ministring to all these delicate offices of nature ; particularly the artificial conformation of the intestines might deserve a special enquiry, their tunicks, glands, fibres traversing one another (*ccc*), and peristaltick motion in all creatures ; and their cochleous passage (*ddd*) to retard the motion of the chyle, and to make amends for the shortness of the intestines, in such creatures who have but one gut ; together with many other accommodations of nature in particular animals that might be mentioned. But it shall suffice to have given only a general hint of those curious and admirable works of God. From whence it is abundantly manifest, how little

(*ccc*) These, although noble contrivances and works of God, are too many to be insisted on ; and therefore I shall refer to the anatomists, particularly Dr. *Willis Pharmaceut.* Dr. *Cole*, in *Phil. Transf.* N<sup>o</sup> 125. and Mr. *Cowper*'s elegant cut in *Anat. tab.* 34, 35. and *Append. fig.* 39, 40.

(*ddd*) In the Thorn-back, and some other fishes, it is a very curious provision that is made to supply the paucity and brevity of the guts ; by the perforation of their single gut, going not strait along, but round, like a pair of winding-stairs ; so that their gut, which seems to be but a few inches long, hath really a bore of many inches. But of these, and many other noble curiosities and discoveries in anatomy, the reader will, I hope, have a better and larger account from the curious and ingenious Dr. *Dowglas*,\* who is labouring in these matters.

little weight there is in the former atheistical objection. Which will receive a further confutation from the

VI. and last thing relating to food, that I shall speak of, namely, The great sagacity of all animals, in finding out, and providing their food. In Man, perhaps, we may not find any thing very admirable, or remarkable in this kind, by means of his reason and understanding, and his supremacy over the inferior creatures; which answereth all his occasions relating to this business: But then even here the Creator hath shewed his skill, in not overdoing the matter; in not providing man with an unnecessary apparatus, to effect over and over again what is feasible by the reach of his understanding, and the power of his authority.

But for the inferior creatures, who want reason, the power of that natural instinct, that sagacity (*eee*) which the Creator hath imprinted upon them; doth amply compensate that defect. And here we shall find a glorious scene of the divine wisdom, power, providence and care, if we view the various instincts of beasts, great and small, of birds, insects, and reptiles (*fff*). For among every species of them,  
we

(*eee*) ‘ Quibus bestiis erat is cibus, ut alius generis bestiis vescerentur, aut vires natura dedit, aut celeritatem: data est quibusdam etiam machinatio quædam, atque solertia, &c. Cic. *de nat. deor.* l. 2. c. 48,

(*fff*) Among reptiles that have a strange faculty to shift for food, &c. may be reckoned Eels, which,  
although

we may find notable acts of sagacity, or instinct, proportional to their occasions for food. Even among those whose food is near at hand, and easily come at; as grass and herbs; and consequently have no great need of art to discover it; yet, that faculty of their accurate smell and taste, so ready at every turn, to distinguish between what is salutary, and what pernicious (ggg), doth justly deserve praise. But for such animals, whose food is not so easily come at, a variety of wonderful instinct may

although belonging to the waters, can creep on the land from pond to pond, &c. Mr. *Mosely* of *Mosely* saw them creep over the meadows, like so many snakes from ditch to ditch; which he thought, was not only for bettering their habitation, but also to catch snails in the grass. *Plot's history of Staffordshire*, c. 7. § 32.

And as early as the year 1125, the frost was so very intense, that the Eels were forced to leave the waters, and were frozen to death in the meadows. *Vide Hakewill's Apol. l. 2. chap. 7. § 2.*

(ggg) 'Enumerare possum, ad pastum capeffendum conficiendumque, quæ sit in figuris animalium & quàm solers, subtilisque descriptio partium, quamque admirabilis fabrica membrorum. Omnia enim quæ intus inclusa sunt, ita nata, atque ita locata sunt, ut nihil eorum supervacaneum sit, nil ad vitam retinendam non necessarium. Dedit autem eadem natura belluis & sensum, & appetitum, ut altero conatum haberent ad naturales pastus capeffendos; altero secernerent pestifera à salutaribus.' *Cic. de nat. deer. l. 2, c. 37. See book iv. chap. 4.*

may be met with, sufficient to entertain the most curious observer. With what entertaining power and artifice do some creatures hunt (*bbb*), and pursue their game and prey ! and others watch and way-lay theirs (*iii*) ! With what prodigious sagacity do others grope for it

(*bbb*) It would be endless to give instances of my own and others observations, of the prodigious sagacity of divers animals in hunting, particularly hounds, setting-dogs, &c. one therefore shall suffice, of Mr. Boyle's ; viz. ' A person of quality----- to ' make a trial, whether a young Blood-hound was ' well instructed,----caused one of his servants---- ' to walk to a town four miles off, and then to a ' market-town three miles from thence.----- The ' dog, without seeing the man he was to pursue, ' followed him by the scent to the above-mentioned ' places, notwithstanding the multitude of market- ' people that went along in the same way, and of ' travellers that had occasion to cross it. And when ' the Blood-hound came to the chief market-town, ' he passed through the streets, without taking notice of any of the people there, and left not till ' he had gone to the house, where the man he ' sought rested himself, and found him in an upper- ' room, to the wonder of those that followed him.' Boyle *determ. nat. of effluv. chap. 4.*

(*iii*) There are many stories told of the craft of the Fox, to compass his prey : of which *Ol. Magnus* hath many ; such as feigning the barking of a dog, to catch prey near the houses ; feigning himself dead, to catch such animals as come to feed upon him ; laying his tail on a wasp-nest, and then rubbing it hard against a tree, and then eating the

Wasps

it under ground, out of sight, in moorish places, in mud and dirt (*kkk*) ; and others dig and delve for it, both above (*lll*), and under the surface of the drier lands (*mmm*) ! and how curious

Wasps so killed : Ridding himself of Fleas, by gradually going into the water, with a lock of wool in his mouth, and so driving the Fleas up into it, and then leaving it in the water : By catching Crabfish with his tail, which he saith he himself was an eye-witness of ; ‘ Vidi & ego in Scopulis Norvegiæ ‘ vulpem, inter rupes immissâ caudâ in aquas, plures educere cancos, ac demum devorare.’ Ol. Mag. *bist.* l. 18. c. 39, 40.

But *Pliny*’s fabulous story of the Hyæna out-does these relations of the Fox. ‘ Sermonem humanum ‘ inter pastorum stabula assimulare, nomenque aliqujus addiscere, quem evocatum foras laceret. Item ‘ vomitionem hominis imitari ad sollicitandos canes ‘ quos invadat.’ Plin. *Nat. bist.* l. 8. c. 30.

(*kkk*) This do Ducks, Woodcocks, and many other fowls, which seek their food in dirty, moorish places. For which service they have very remarkable nerves reaching to the end of their bills. Of which see *book vii. chap. 2. note (c)*.

(*lll*) Swine, and other animals that dig, have their noses made more tendinous, callous, and strong for this service, than others that do not dig. They are also edged with a proper, tough border, for penetrating and lifting up the earth ; and their nostrils are placed well, and their smell is very accurate, to discover whatsoever they pursue by digging.

(*mmm*) The Mole, as its habitation is different from that of other animals, so hath its organs in every respect curiously adapted to that way of life ;  
particu-



curious and well-design'd a provifion is it of particular large nerves in fuch creatures, adapted to that efpecial fervice !

What an admirable faculty is that of many animals, to difcover their prey at vaft diftances ; fome by their fmell fome miles off (*nnn*) ; and fome by their fharp and piercing fight, aloft in the air, or at other great diftances (*ooo*) ! An inftance of the latter of which God himfelf giveth (*Job xxxix, 27, 28, 29.*) in the inftinct of the Eagle : ‘ Doth the Eagle mount up at  
‘ thy command, and make her neft on high ?  
‘ She

particularly its nofe made fharp, and flender, but withal tendinous and ftrong, &c. But what is very remarkable, it hath fuch nerves reaching to the end of its nofe and lips, as Ducks, &c. have, mentioned above in note (*kkk*). Which pair of nerves I obferved to be much larger in this animal than any other nerves proceeding out of its brain.

(*nnn*) Predacious creatures, as Wolves, Foxes, &c. will difcover prey at great diftances ; fo will Dogs and Ravens difcover carrion a great way off by their fmell. And if (as the fuperftitious imagine) the latter flying over and haunting houfes be a fign of death, it is no doubt from fome cadaverous fmell, thofe Ravens difcover in the air by their accurate fmell, which is emitted from thofe difeafed bodies, which have in them the principles of a fpeedy death.

(*ooo*) Thus Hawks and Kites on land, and Gulls, and other birds, that prey upon the waters, can at a great height in the air fee Mice, little birds and infeeds on the earth and fmall fifhes, Shrimps, &c. in the waters, which they will dart down upon, and take.

‘ She dwelleth and abideth on the rock, upon  
 ‘ the crag of the rock, and the strong  
 ‘ place (ppp). From thence she seeketh her  
 ‘ prey, and her eyes behold afar off.’ What  
 a commodious provision hath the contriver of  
 nature made for animals, that are necessitated  
 to climb for their food ; not only in the struc-  
 ture of their legs and feet, and in the strength  
 of their tendons and muscles, acting in that  
 particular

(ppp) Mr. Ray gives a good account of the nidifica-  
 tion of the Chrysaëtos, ‘ Caudâ annulo albo cinctâ.  
 ‘ Hujus nidus ann. 1668. in sylvis prope Der-  
 ‘ wentiam, &c. inventus est è bacillis seu virgis lig-  
 ‘ neis grandioribus compositus, quorum altera ex-  
 ‘ tremitas rupis cujusdam eminentiæ, altera duabus  
 ‘ Betulis innitebatur,----erat nidus quadratus, duas  
 ‘ ulnas latus,---in eo pullus unicus, adjacentibus  
 ‘ cadaveribus unius agni, unius leporis, & trium  
 ‘ Grygallorum pullorum.’ *Synops. method. avium*,  
 p. 6. And not only Lambs, Hares, and Grygalli,  
 but Sir Robert Sibbald tells us, they will seize Kids  
 and Fawns ; yea, and children too : Of which he  
 hath this story of an Eagle in one of the *Orcades*  
 islands, ‘ Quæ infantulum unius anni pannis invo-  
 ‘ lutum arripuit (quem mater tessellas ustibiles pro  
 ‘ igne allatura momento temporis deposuerat in loco  
 ‘ *Houton-Head* dicto) eumque deportasse per 4 mil-  
 ‘ liaria passuum ad *Hoiam* ; quâ re ex matris ejula-  
 ‘ tibus cognitâ, quatuor viri illuc in naviculâ pro-  
 ‘ secti sunt, & scientes ubi nidus esset, infantulum  
 ‘ illæsum & intactum deprehenderunt.’ *Pred. nat.*  
*bist. Scot. l. 3. part. II. p. 14.*

particular office (*qqq*) ; but also in the peculiar structure of the principal parts, acting in the acquist of their food (*rrr*) ! What a provision also is that in nocturnal birds and beasts, in the peculiar structure of their eyes (*sss*) (and we may perhaps add the accuracy of their smell too) whereby they are enabled to discover their food in the dark ? But among all the instances we have of natural instinct, those instincts, and especial provisions made to supply

(*qqq*) See in *book vii. chap. i. note (l)*. the characteristics of the Woodpecker-kind.

(*rrr*) ‘ The contrivance of the legs, feet, and nails [of the *Opposum*] seems very advantageous. ‘ to this animal in climbing trees (which it doth ‘ very nimbly) for preying upon birds.’ But that which is most singular in this animal, is the structure of its tail, to enable it to hang on boughs. ‘ The spines, or hooks----in the middle of the under side of the vertebræ of the tail, are a wonderful piece of nature’s mechanism. The first three ‘ vertebræ had none of these spines, but in all the rest they were to be observed.---They were placed ‘ just at the articulation of each joint, and in the middle from the sides.----For the performing this ‘ office [of hanging by the tail] nothing, I think, ‘ could be more advantageously contrived. For ‘ when the tail is twirled or wound about a stick, ‘ this hook of the spinæ easily sustains the weight, ‘ and there is but little labour of the muscles required, only enough for bowing or crooking the ‘ tail.’ This, and more to the same purpose, See in Dr. *Tyson’s Anatomy of the Oposum*, in *Philos. Transact.* N<sup>o</sup> 239.

(*sss*) See before, *chap. ii. note (z)*, (*aa*), (*bb*).

ply the necessities of helpless animals, do in a particular manner demonstrate the great Creator's care. Of which I shall give two instances.

1. The provision made for young creatures. That *sympathy*, that natural affection, so connatural to all, or most creatures towards their young (*tit*), what an admirable noble principle is it, implanted in them by the wise Creator?

(*tit*) ' Quid dicam quantus amor bestiarum fit in educandis custodiendisque iis, quæ procreaverint, usque ad eum finem, dum possint seipsa defendere?' And having instanced in some animals, where this care is not necessary, and accordingly is not employed, he goes on, ' Jam Gallinæ, avesque reliquæ, & quietum requirunt ad pariendum locum, & cubilia sibi, nidosque construunt, eosque quàm possunt mollissimè substernunt, ut quàm facillimè ova serventur. Ex quibus pullos cùm excluderint, ita tuentur, ut & pennis foveant, ne frigore lædantur, & si est calor, à sole se opponant.' Cic. *de nat. deor.* l. 2. c. 51, 52.

To this natural care of parent-animals to their young, we may add the returns made by the young of some towards the old ones. *Pliny* saith of Rats, ' Genitores suos fessos senectâ, alunt insigni pietate.' *Nat. hist.* l. 8. c. 57. So Cranes, he saith, ' Genitricum senectam invicem educant.' *L.* 10. c. 23.

This St. *Ambrose* takes notice of in his *Hexameron*, and *Ol. Magnus* after him, ' Depositi patris artus, per longævum senectutis plumis nudatos circumstans soboles pennis propriis foveat----- collatio cibo pascit, quando etiam ipsa naturæ reparat dispendia, ut hinc inde senem sublevantes, fulcro alarum suarum ad volandum exerçant, & in pri-

tor ? By means of which, with what alacrity do they transact their parental ministry ? With what care do they nurse up their young ; think no pains too great to be taken for them, no dangers (*uuu*) too great to be ventured upon for their guard and security ? How carefully will they lead them about in places of safety, carry them into places of retreat and security ; yea, some of them admit them into their own bowels (*www*) ? How will they caress them with

‘ *stinus usus defueta membra reducant.*’ For which reason this bird is denominated *Pia*. *Vide Ol. Mag. Hist. l. 19. c. 14.*

Hereto may be added also the conjugal *Στοργή* of the little green *Æthiopian Parrot*, which Mr. Ray describes from *Clusius*. ‘ *Fœmellæ senescentes (quod valdè notabile) vix edere volebant, nisi cibum jam à mare carptum, & aliquandiu in prolobo retentum, & quasi coctum rostro suo exciperent, ut Columbarum pulli à matre ali. solent.*’ *Synops. meth. av. p. 32.*

(*uuu*) The most timid animals, that at other times abscond, or hastily fly from the face of man, dogs, &c. will, for the sake of their young, expose themselves. Thus among fowls, Hens will assault, instead of fly from, such as meddle with their brood. So Partridges, before their young can fly, will drop frequently down, first at lesser, and then at greater distances, to dodge and draw off dogs from pursuing their young.

(*www*) The Opossum hath a curious bag on purpose for the securing and carrying about her young. There are belonging to this bag two bones (not to be met with in any other skeleton) and four pair of muscles ;

with their affectionate notes, lull, and quiet them with their tender parental voice, put food into their mouths, suckle them, cherish and keep them warm, teach them to pick, and eat, and gather food for themselves; and, in a word, perform the whole part of so many nurses, deputed by the sovereign lord and preserver of the world, to help such young and shiftless creatures, till they are come to that maturity, as to be able to shift for themselves?

And as for other animals (particularly insects, whose fire is partly the sun, and whose numerous offspring would be too great for their parent-animals care and provision) these are so generated, as to need none of their care, by reason they arrive immediately to their *Ἠλικία*, their perfect, adult state, and are able to shift for themselves. But yet, thus far their parental instinct (equivalent to the most rational care and foresight) doth extend, that the old ones do not wildly drop their eggs and sperm any where, at all adventures, but so cautiously reposit it in such commodious places (some in the waters, some on flesh, some on

muscles; and some say the teats lie therein also. Dr. *Tyson* Anat. of the *Opoff*. in *Pbil. Trans.* N<sup>o</sup> 239. where he also, from *Oppian*, mentions the Dog-fish, that upon any storm or danger, receives the young ones into her belly, which come out again when the fright is over. So also the *Squatina* and *Diaucus*, the same author saith, have the same care for their young, but receive them into different receptacles.



on plants) proper and agreeable to their species (*xxx*) ; and some shut up agreeable food in their nests, partly for incubation, partly for food (*yyy*), that their young in their Aurelia, or Nympha state, may find sufficient and agreeable food to bring them up, till they arrive to their maturity.

Thus far the parental instinct and care.

Next we may observe no less in the youth themselves, especially in those of the irrational animals. Forasmuch as the parent-animal is not able to bear them about, to cloath them, and to dandle them, as man doth ; how admirably hath the Creator contrived their state, that those poor young creatures can soon walk about, and with the little helps of their dam, shift for, and help themselves ? How naturally do they hunt for their teat, suck, pick (*zzz*), and take in their proper food ? But

(*xxx*) See book viii. chap. 6.

(*yyy*) See chap. xiii. note (*e*).

(*zzz*) There is manifestly a superintending providence in this case, that some animals are able to suck as soon as ever they are born, and that they will naturally hunt for the teat before they are quite gotten out of the secundines, and parted from the navel-string, as I have seen. But for Chickens, and other young birds, they not being able immediately to pick till they are stronger, have a notable provision made for such a time, by a part of the yolk of the egg being inclosed in their belly, a little before their exclusion or hatching, which serves for their nourishment, till they are grown strong enough to pick up meat. *Vide* book vii, chap. 4.

But for the young of man, their parents reason, joined with natural affection, being sufficient to help to nurse, to feed, and to cloath them ; therefore they are born helpless, and are more absolutely, than other creatures, cast upon their parents care (aaaa). A manifest act and designation of the divine providence.

2. The other instance I promised, is the provision made for the preservation of such animals as are sometimes destitute of food, or in danger of being so. The winter is a very inconvenient, improper season, to afford either food or exercise to insects, and many other animals. When the flowery fields are divested of their gaiety ; when the fertile trees and plants are stripp'd of their fruits, and the air, instead of being warmed with the cherishing beams of the sun, is chilled with rigid frost ; what would become of such animals as are impatient of cold ? What food could be found by such as are subsisted by the summer-fruits ? But to obviate all this evil, to stave off the destruction and extirpation of divers species of animals, the infinitely wise preserver of the world hath as wisely ordered the matter ; that, in the first place, such as are impatient of cold, should have such a special structure of their body, particularly of their hearts, and circulation of  
their

(aaaa) ' Qui [infantes] de ope nostrâ ac de divinâ  
' misericordiâ plus merentur, qui in primo statim  
' nativitatis suæ ortu plorantes ac flentes, nil aliud  
' faciunt quam deprecantur,' *Cypr. Ep. ad fid.*

their blood (bbbb), as during that season, not to suffer any waste of their body, and consequently not to need any recruits; but that they should be able to live in a kind of sleepy, middle state, in their places of safe retreat, until the warm sun revives both them and their food together.

The next provision is for such as can bear the cold, but would want food then; and that is in some by a long patience of hunger (cccc), in others by their notable instinct in

(bbbb) I might mention here some of the species of birds, the whole tribe almost of insects, and some among other tribes, that are able to subsist for many months without food, and some without respiration too, or very little: But it may suffice to instance only in the Land-Tortoise, of the structure of whose heart and lungs, see book vi. chap. 5. note (b).

(cccc) ‘Inediam diutissimè tolerat Lupus, ut & alia omnia carnivora, licet voracissima; magnâ utique naturæ providentiâ; quoniam esca non semper in promptu est.’ Ray’s *Synops. quadr.* p. 174.

To the long abstinence mentioned of brute animals, I hope the reader will excuse me, if I add one or two instances of extraordinary abstinence among mankind. One *Martha Taylor*, born in *Derbyshire*, by a blow on the back fell into such a prostration of appetite, that she took little sustenance, but some drops with a feather, from *Christmas* 1667, for thirteen months, and slept but little too all the time. See Dr. *Sampson*’s account thereof, in *Ephem. Germ. T. 3. obs. 173.* To

in laying up food before-hand against the approaching winter (dddd). Of this many entertaining

To this we may add the case of *S. Cbilten*, of *Tinsbury*, near *Batb*, who, in the years 1693, 1696, and 97, slept divers weeks together. And although he would sometimes in a very odd manner, take sustenance, yet would lie a long time without any, or with very little, and all without any considerable decay. See *Phil. Transf.* N<sup>o</sup> 304.

(dddd) They are admirable instincts which the *Sieur de Beauplau* relates of his own knowledge, of the little animals called *Bohaques* in *Ukraine*. 'They make burroughs like Rabbits, and in *October* shut themselves up, and do not come out again till *April*.----They spend all the winter under ground, eating what they laid up in summer.-----Those that are lazy among them, they lay on their backs, then lay a great handful of dry herbage upon their bodies, &c. then others drag those drones to the mouths of their burroughs, and so those creatures serve instead of barrows, &c. I have often seen them practise this, and have had the curiosity to observe them whole days together.-----Their holes are parted like chambers; some serve for store-houses, others for burying-places, &c. Their government is nothing inferior to that of bees, &c. They never go abroad without posting a centinel upon some high ground, to give notice to the others whilst they are feeding. As soon as the centinel sees any body, it stands upon his hind legs, and whistles.' *Beauplau's description of Ukraine*, in Vol. I. of the collection of voyages, &c.

A like instance of the northern *Galli Sylvestres*, see in *chap. 13. note (g)*.

As for the scriptural instance of the *Ant*, see hereafter *book viii. chap. 5. note (d)*.

taining examples may be given ; particularly we may, at the proper season, observe not only the little treasures and holes well-stocked with timely provisions, but large fields (cccc) here and there throughout bespread with considerable numbers of the fruits of neighbouring trees, laid carefully up in the earth, and covered safe, by the provident little animals inhabiting thereabouts. And not without pleasure, have I seen and admired the sagacity of other animals, hunting out those subterraneous fruits, and pillaging the treasures of those little provident creatures.

And now, from this bare transient view of this branch of the great Creator's providence and government, relating to the food of his creatures, we can conclude no less, than that since this grand affair hath such manifest strokes of admirable and wise management, that since this is demonstrated throughout all ages and places, that therefore it is God's handy-

(cccc) I have in Autumn, not without pleasure, observed, not only the great sagacity and diligence of Swine, in hunting out the stores of the Field-mice ; but the wonderful precaution also of those little animals, in hiding their food beforehand against winter. In the time of acorns falling, I have, by means of the Hogs, discovered, that the Mice had, all over the neighbouring fields, treasured up single acorns in little holes they had scratched, and in which they had carefully covered up the acorn. These the Hogs would, day after day, hunt out by their smell.

handy-work. For how is it possible that so vast a world of animals should be supported, such a great variety equally and well supplied with proper food, in every place fit for habitation, without an especial superintendency and management, equal to, at least, that of the most prudent steward and householder? How should the creatures be able to find out their food when laid up in secret places? And how should they be able to gather even a great deal of the common food, and at last to macerate and digest it, without peculiar organs adapted to the service? and what less than an infinitely wise God could form such a set of curious organs, as we find every species endowed with, for this very use? Organs so artificially made, so exquisitely fitted up, that the more strictly we survey them, the more accurately we view them (even the meanest of them, with our best glasses) the less fault we find in them, and the more we admire them: whereas the best polished, and most exquisite works, made by human art, appear thro' our glasses, as rude and bungling, deformed and monstrous; and yet we admire them, and call them works of art and reason. And lastly, what less than rational and wise, could endow irrational animals with various instincts, equivalent in their special way to reason itself? Infomuch that some from thence have absolutely concluded, that those creatures had some glimmerings of reason. But it is manifestly



festly instinct, not reason, they act by, because we find no varying, but that every species doth naturally pursue at all times the same methods and way, without any tutorage or learning: Whereas Reason, without instruction, would often vary, and do that by many methods, which Instinct doth by one alone. But of this more hereafter.

*The End of the First Volume.*



